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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXII.

Wednesday, 16*th November* 1892.—JOHNSON SYMINGTON, Esq., M.D., F.R.S.E., retiring Vice-President, in the Chair.

The retiring Vice-President delivered the following opening address:—

GENTLEMEN,—It is my duty, as retiring Vice-President, to deliver the opening address of this, the 122nd Session of the Royal Physical Society, and I have selected as my subject the Cerebral Convolutions in the Primates—a review of our knowledge of their anatomy and physiology. The intimate association between the cerebral convolutions and the mental processes must ever render their study one of general interest, while the great activity which has been displayed in the investigation of their arrangement and functions by the anatomist, physiologist, and pathologist, and the rich harvest which their united labours have gathered, afford abundant material for the illustration of the methods and results of scientific work.

In 1771, when this Society was founded, cerebral anatomy was in its infancy. Notwithstanding the labours of Vesalius, Willis, Bidloo, Vieussens, Tarin, and others, our knowledge of the ordinary naked-eye anatomy of the human brain was very crude and imperfect. In our own city, Alexander Monro secundus, a man of European reputation, occupied the Chair of Anatomy in the University. Twelve years later, in 1783, he published his great work, entitled "Observations on the Structure and Functions of the Nervous System." In this work Monro made no attempt to show that the convolutions and fissures of the human brain were arranged in any definite or regular manner. In fact, at this time anatomists believed them to be as irregular and indefinite as the coils of the small intestine, or a dish of macaroni.

Three years after the appearance of Monro's "Observations," Vicq d'Azyr published in Paris his "Anatomie et Physiologie du Cerveau," as the first volume of a complete treatise on anatomy and physiology which he intended to issue. Although the only volume of the series which ever appeared, it is in itself an imperishable monument of his industry, learning, manipulative dexterity, and accurate observation. It consists of five cahiers of plates and three cahiers of text. The five cahiers of figures contain thirty-five coloured plates, and the same plates in black with 111 pages of explanation. As an atlas of the naked-eye anatomy of the adult human brain, it far surpassed in the number, the artistic excellence, and the fidelity to nature of the drawings, any previously published work on the subject. The plates are life-size, and Vicq d'Azyr spared no pains to render them accurate. Many of them, especially the views of the brain from above, were made from dissections of this organ while still within the cranial cavity. By this means he preserved the natural shape and relations of its different parts. A study of the text accompanying the plates will show that he was thoroughly familiar with the researches of his predecessors. He makes frequent reference to the works of Vesalius, Eustachius, Etienne, Willis, Bidloo and Cowper, Morand, Tarin, Sœmmerring, Haller, and Monro, and points out both the merits and the imperfections of their illustrations. It is not surprising to hear that Vicq d'Azyr's work created a considerable sensation when it appeared, and has ever since been a fertile source for the illustrations of our text-books. It must be admitted, however, that his illustrations and descriptions of the convolutions are very imperfect, and not to be compared with those he gives of the other parts of the brain. He appears to have been unable altogether to shake off the traditional view of the convolutions as irregular and indefinite folds of the cerebral cortex. Confining his observations, as he appears to have done, to the adult human brain, it is surprising that he succeeded as well as he did. Thus he recognised the convolutions of the corpus callosum, the hippocampal and uncinate convolutions with the gyrus dentatus, and distinguished the ascending frontal and ascending parietal convolutions by their direction from those in front and behind. He doubted the propriety of dividing the cortex into lobes, preferring to map out the convex surface of the cerebral hemispheres into three regions according to their position subjacent to the frontal, parietal, and occipital bones. In this he was more logical than some of his predecessors, for neither he nor they made any attempt to trace the course of the cerebral fissures. He marks a number of the convolutions, but does not label any of the fissures between them. Broca gives him credit for representing the fissure of Rolando, but he did so very imperfectly.

In 1810 Gall and Spurzheim published their well-known "Anatomie et Physiologie du système nerveux en general et du cerveau en particulier." One might naturally have expected that these investigators would have paid special attention to the configuration of the cortex, but such is not the case; indeed, they added nothing to our knowledge of the cerebral convolutions or fissures. They appear to have been so enamoured by their peculiar phrenological theories as not only to neglect the careful study of the external surface of the brain, but even to distort anatomical facts so as to make them appear to favour their views. Thus, as Leuret[1] shows, in giving illustrations of the brains of the lion and tiger (see plate xxxiii., figs. 4 and 5 of their work), Gall and Spurzheim greatly exaggerate the size of the parts of the brain lying behind the fissure of Sylvius, portions of the cortex to which they attributed the functions of destruction and cunning.

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[1] Anatomie comparée du système nerveux, vol. i., p. 366.

T. Tiedemann,[1] writing in 1816, showed the slender anatomical basis upon which their theories were based. He states that while Gall urged the importance of comparative anatomy in the investigation of the functions of the brain, he himself only described the nervous system of a worm, of a hen, and of a few mammals, and even these few imperfectly.

In 1831, Rolando, an Italian anatomist, gave the first clear and accurate representation of the cerebral fissure in the human brain, now usually named after him.

The adult human convolutions are so highly developed and so complex in their arrangement, that one cannot be surprised at the failure of the older anatomists to detect order in such apparent irregularity. It was hopeless to expect any solid advance merely by the study of adult human brains. It was only through comparative anatomy and development that progress in this direction was possible.

Many of the older anatomists were well aware of the light which was thrown upon the structure of the human brain by a study of lower forms, and they frequently give illustrations of the brains of certain of the domestic animals. In such orders as the Carnivora and Ungulata, the general arrangement of the convolutions differ greatly from that of man; their evolution has followed a path of its own, so that the attempts to determine their corresponding homologies is attended with special difficulties, even if it be not entirely futile. In the Primates, however, we have a tolerably regular evolution from the nearly smooth brain of some of the New-World monkeys up to the complex folds found in man. Even in the lower Primates, where the convolutions are few in number, the general development of the cerebral hemispheres and their extension backwards beyond the cerebellum indicate a higher type than the convoluted brain of many lower mammals.

It is to Leuret and Gratiolet that we are indebted for the first important work on the comparative anatomy of the convolutions, and for perceiving the necessity of an examination of the fissures as well as the convolutions. Leuret[1] gave beautiful drawings of the brains of numerous mammals, such as the beaver, rabbit, mole, paca, agontis, hedgehog, squirrel, cat, lion, panther, bear, otter, ferret, sheep, ox, horse, kangaroo, roebuck, deer, wild boar, seal, porpoise, elephant, and papio. The papio was the only monkey that Leuret had studied, but he recognised very clearly the fact that its convolutions are arranged fundamentally the same as those of man. In the explanation to plate xv. of his Atlas, which contains several figures of this animal's brain, he writes: "It is a very small human brain, or rather a very great brain of the human fœtus. The cerebral convolutions are the same in number as in man, but they are not more folded than those of a fœtus of the sixth or seventh month. One recognises three anterior convolutions, three posterior convolutions, two superior convolutions, an internal convolution, and a group of suborbital convolutions."

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[1] Anatomie und Bildungsgeschichte des Gehirns im Fœtus des Menschen, Nürnberg, 1816.

In plate xvi. he shows that the same convolutions exist in man. It was Leuret who first described the fissure of Rolando. Rolando appears to have been the first anatomist who figured this fissure correctly, but he did not describe it. Leuret failed to distinguish the parieto-occipital fissure or the occipital lobe. He died before finishing his work on the comparative anatomy of the nervous system, the second volume being entirely written by Gratiolet. Gratiolet also published a "Memoir sur les plis cérébraux de l'homme et des Primates" in 1854. In this classical memoir Gratiolet made a very careful and elaborate comparison of the relative development of the convolutions of the human brain in a well-developed European, a Bosjeswoman, microcephalic idiots, and fœtuses. He also investigated their arrangement in the chimpanzee, the orang-outang, and the gibbon, as well as various monkeys of both the Old and the New World. Anatomists previous to Leuret and Gratiolet had divided the outer surface of the cerebral hemispheres into lobes, the extent and boundaries of which were determined by the bones of the skull which covered them. The five lobes described by Gratiolet in man and the higher apes, although named, with one exception, from the bones with which they were specially related, were based upon fissures in the brain itself. This, as Broca[1] very justly observes, constituted a very important advance in the study of the convolutions. The five cerebral lobes described by Gratiolet are still, with some modifications, generally accepted by anatomists.

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[1] Anatomie comparée du système nerveux, considérée dans sans rapports avec l'intelligence.

Gratiolet, from his comparative study of the Primate brain, was led to divide the gyri, from the order of their appearance, into primary and secondary. By this means he was able to analyse the richly convoluted brains of the higher races of mankind, and to explain the steps of their evolution from simpler forms. Gratiolet's work was published about forty years ago, and since then most of the leading anatomists in this and other countries have contributed to the task of placing our knowledge of the comparative anatomy of the cerebral convolutions upon a sound morphological basis. Amongst these, special mention may be made of Gervais and Broca in France, of Rudolph Wagner, Bischoff, Echer, Pansch, Benedict, Zuckerkandl, Waldeyer, Schwalbe, and Eberstaller in Germany and Austria; of Guldberg in Norway; of Giacomini in Italy; of Burt Wilder in America; and of Owen, Huxley, Flower, Turner, Marshall, Rolleston, and Cunningham in this country. In connection with this subject, I may perhaps be allowed to refer specially to the work that has been done by one of our former presidents—Sir William Turner. As early as 1865 he read a paper before the Royal Society of Edinburgh, entitled, "Notes more especially on the Bridging Convolutions in the Brain of the Chimpanzee," and in the following year he delivered a lecture before the Royal Medical Society on "The Convolutions of the Human Cerebrum topographically considered," which was published in the *Edinburgh Medical Journal* for June 1866. In this lecture Sir William Turner not only gave a very valuable summary of the state of our knowledge at that time, but he also added much original matter, and introduced several new terms which have since been generally adopted in the descriptive anatomy of the cerebral cortex. Two years ago, his position as one of the leading authorities in this department of anatomy was recognised by his being invited to deliver an address on this subject before the Anatomical Section of the International Medical Congress held in Berlin. This address was published in the *Journal of Anatomy and Physiology* for October 1890, and also in the *Transactions* of the Berlin Congress. It contains a very extensive and valuable series of investigations into the arrangement of the rhinencephalon and pallium in numerous animals, and is illustrated by a large number of original figures.

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[1] Note sur la topographique cérébrale et sur quelques points de l'histoire des circonvolutions—Bulletin de l'Acad de Médecine, 1876.

Turning now from the comparative anatomy of the adult brain to its developmental history, we shall find that this department has likewise engaged the attention of many earnest investigators, and shows a good record of work already accomplished. Of course, the very early stages in the development of the brain could not be ascertained until the general introduction of the microscope as an instrument of research, the discovery of suitable hardening and staining reagents, and of improved methods of section cutting; but even before these important aids had been adopted in our laboratories, the main features of cerebral development had been traced.

We have seen that the publication of Vicq d'Azyr's work in 1787 provided the anatomist with an accurate and a beautifully illustrated account of the naked-eye anatomy of the adult brain. About thirty years later, in 1816, the science of embryology was enriched by Frederick Tiedemann's memoir on the "Anatomie und Bildungsgeschichte des Gehirns im Fœtus des Menschen." This was the first work of any importance dealing in a systematic manner with the development of the human brain. It affords an admirable illustration of the fact that the introduction of improved methods of research are soon followed by fresh discoveries. Shortly before Tiedemann began to work at the development of the brain, Reil had shown the value of spirits-of-wine as a hardening agent for the central nervous system, and Tiedemann used this fluid for the embryoes he obtained for his researches. This method was invaluable for his naked-eye dissections, but it did not enable him to determine the condition of the nervous system in the first month of intra-uterine life. He described the general external form of the human embryo at the end of the fourth week, but came to the conclusion that it then possessed neither brain nor spinal cord, their place being taken by a clear fluid. He, however, gave an excellent description, with drawings, of the general form of the fœtal brain from the twelfth week to the seventh month. It is now well known that the external surface of the cerebral hemispheres, from about the tenth week to the end of the fourth month, present certain fissures which Tiedemann was the first to figure. He was, however, wrong in supposing that they were the rudiments of the permanent fissures, for, as Professor Cunningham has pointed out, J. T. Meckel, a year previously, had correctly described them as merely temporary foldings of the cerebral wall. Tiedemann does not appear to have investigated to any great extent the surface of the hemispheres from the sixth to the ninth month, a period during which the development of the fissures and convolutions is most active. These omissions, however, were to a great extent supplied by Reichart in 1859, Echer in 1869, and Mihalkovics in 1877.

Notwithstanding all that has been done in the comparative and developmental anatomy of the cerebral cortex, it is still a fruitful field for the earnest investigator.

The memoir published this year by Professor D. J. Cunningham[1] shows what valuable and interesting results it can still yield. In his memoir, Cunningham has given the results of his investigations regarding the development, comparative anatomy, and topographical relations of the principal fissures in the Primate brain, together with an able summary and discussion of the work of previous observers.

It is undoubtedly the most important contribution to the morphology of the Primate brain that has appeared for many years. Many interesting points, however, still require elucidation. Indeed, even now we know practically nothing from direct observations regarding the stages in the development of the cerebral fissures and convolutions in the anthropoid apes, and even in the lower apes our knowledge is very incomplete.

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[1] Contributions to the Surface Anatomy of the Cerebral Hemispheres—Royal Irish Academy, Cunningham Memoirs, 1892.

We have seen that to the French school of anatomists, as represented by Leuret and Gratiolet, is due the honour of having been the first to show the true scientific method of studying the cerebral fissures and convolutions, and of having applied those methods with such brilliant results. To another Frenchman, the illustrious Broca, we owe the first demonstration of the doctrine of localisation of function in the cerebral cortex, a discovery destined to prove not only of great scientific interest, but also of immense importance in practical medicine and surgery. So long as the anatomy of the cerebral cortex was unknown, its physiology was of necessity, to a large extent, a matter of vague speculation. Even for some time after the publication, in 1854, of Gratiolet's work on the cerebral convolutions, clinical and pathological observations and physiological experiments were believed to prove that all parts of the cerebral cortex had the same functional value. Numerous cases were related in which large portions of the surface of the cerebrum were destroyed by accident or disease without producing any apparent mental disturbance. Thus Dr Bigelow described, in the *American Journal of the Medical Sciences* for July 1850, what is generally quoted as the "American crowbar case." A young man was hit by a bar of iron at the left angle of his jaw. The piece of iron entering at the angle of the jaw passed through the anterior part of the left cerebral hemisphere, and emerged at the top of his head in the left frontal region. The man speedily recovered, and lived for thirteen years after the accident, without manifesting any special cerebral symptoms.

Flourens, the great French physiologist, found that he could remove limited portions of the cortex in animals without destroying any one of its functions, and that, according to the amount removed, all its functions were gradually impaired and finally destroyed. According to his experiments, mechanical stimulation of the cortex produced little or no effect.

In 1861 Dr Paul Broca published the first of a series of papers, "Sur le Siége de la Faculté du Langage articulé," in which he demonstrated, from clinical and pathological observation, the fact that the centre for speech was situated in the posterior part of the inferior frontal convolution. In cases of a lesion in this part of the cortex the patient cannot give articulate expression to the object he desires or is requested to name, although he may know the proper word-symbol for it. In 1869 Dr Hughlings-Jackson, from observations of cases of unilateral and localised epileptiform convulsions, came to the conclusion that there were motor centres in the cortex, the irritation of which caused the convulsive phenomena.

The views of Hughlings-Jackson were soon confirmed and greatly extended by the experiments of Hitzig and Fritsch in Germany, and Ferrier in this country. In 1870 Hitzig and Fritsch published an account of their experiments on the lower animals, in which portions of the exposed brain cortex were stimulated by a continuous current, when the phenomena of contraction of certain groups of muscles was observed on opening and closing the current. In 1873 Ferrier, to test the views of Hughlings-Jackson, undertook a somewhat similar series of experiments, using, however, a Faradic instead of a continuous current. He mapped out upon the cerebral cortex of the macacque monkey a large number of centres, each of which, on stimulation, was followed by certain definite movements.

From experiments on various animals, it has been shown that this localisation becomes more definite as we pass from lower to higher forms. Thus it is hardly recognisable in the frog, and gradually becomes more distinct in the bird, rabbit, and dog. The macacus shows a decided advance on the dog, but even in it the differentiation is still very incomplete.

"If we explore, for instance, the area for the wrist, we find that its limits are ill defined. In some parts of the area we obtain movements of the wrist only, but in other parts of the area stimulation produces not only movements of the wrist but also of the shoulder or of the digits or of the neck; and so with the other areas. If, however, not a macacus or other ordinary monkey, but the more highly-developed orang-outang be taken as the subject of experiments, the differentiation is found to be distinctly advanced; the several areas are more sharply defined, and what is important to note, the respective areas tend to be separated from each other by portions of cortex, stimulation of which gives rise to no movement at all" (Foster, "A Text-Book of Physiology," 5th edition, pt. iii., p. 1043).

It is of course impossible to repeat these experiments on man, but they have unquestionably given an immense impetus to the clinical and pathological investigation of injuries and diseases of the human cerebral cortex, and it has been abundantly demonstrated that similar motor centres exist in man. The application of these facts to the treatment of injuries and diseases of the cerebral cortex by Macewen, Horsley, and others, constitute one of the greatest triumphs of modern surgery.

In the remarkable address which Professor Macewen delivered at the annual meeting of the British Medical Association in August 1888, numerous cases were shown in which the exact seat of a lesion in the cerebral cortex had been diagnosed and successfully treated.

There are few questions in morphology that can equal in scientific and practical interest those connected with the determination of the relation between the cerebral fissures and convolutions in man and the higher apes, and I propose now to briefly consider some of the more important results that have been arrived at from a study of their comparative anatomy. We have seen that in 1854 Gratiolet figured the brains of the chimpanzee, orang, and gibbon, and he came to the conclusion that, not only the main lobes and fissures of the human brain were represented in these apes, but also all the principal convolutions and secondary fissures; the main peculiarity of the human brain being a more convoluted arrangement of the individual convolutions, and an increase in the number and complexity of the "plis de passage," or bridging convolutions. These bridging, or annectant, convolutions are especially well developed between the parietal and occipital lobes. In plate xii. of his Atlas, Gratiolet gave figures of numerous Primate brains, and marked the corresponding lobes and convolutions in the different brains by similar colours, so that the points of similarity could be readily appreciated.

Soon after the publication of Gratiolet's work, Professor Owen, in a paper read before the Linnean Society of London, "On the Characters, Principles of Division, and Primary Groups of the Class Mammalia," endeavoured to prove that the growth backwards of the cerebral hemispheres was so marked in man that a posterior lobe "is peculiar to the genus *homo*, and equally peculiar is the posterior horn of the lateral ventricle and the hippocampus which characterise the hind lobe of each hemisphere." In virtue of these special cerebral characters, Owen placed man in a separate subclass of the Mammalia, which he termed Archencephala. These views were vigorously controverted by Professors Huxley and Flower, who had little difficulty in proving that the possession of a posterior lobe, a posterior horn, and a hippocampus minor, were not peculiar to man, but existed in many apes. No one has contributed more to our knowledge of the anatomy of the anthropoid apes than Sir Richard Owen, but his warmest admirers must admit that anatomical facts lend no support to his statements on this subject. The most marked character which distinguishes the brain of man from that of the anthropoid apes is to be found in its large size, both absolutely and relatively, to the body weight. When we compare the individual lobes and convolutions, we find many interesting peculiarities in the human brain, but they are all of secondary importance. The contention of Huxley that the differences in the anatomy of man and the higher apes are much less than those between the latter and the lower monkeys, are very strikingly illustrated by a comparison of their brains.

The frontal lobe is now generally regarded as extending backwards to the fissure of Rolando, although Gratiolet placed it anterior to the convolution ascending in front of and parallel with that fissure. Physiologically, the two convolutions bounding the fissure of Rolando are so intimately associated that it is unfortunate that they should be described anatomically as belonging to two different lobes. The discovery by Broca of the centre for speech or phonation in the posterior part of the left inferior frontal convolution in man, and the belief that the frontal lobes are specially connected with the intellectual actions of cognition and volition, have naturally led to a very careful comparison of this part of the brain in man and apes.

In 1861 the late Professor John Marshall,[1] in describing the brain of a young chimpanzee, stated that in this animal the dorsal end of the fissure of Rolando was situated in front of the transverse axis of the hemisphere, while in man it was to a still greater extent behind that axis. Assuming the length of the hemisphere to be represented by 100, the distance from the forepart of the brain to the dorsal end of the fissure of Rolando was estimated by Marshall as 47 in the chimpanzee and 57 in man. In a paper which I read before this Society in 1890, I ventured to doubt the accuracy of this statement, as in a brain of a chimpanzee in my possession this fronto-Rolandic index was 61, or a little more than in the human subject. Professor D. J. Cunningham,[2] by a somewhat different method of measurement, and a more extended series of observations, has confirmed my results. Thus, in the human subject, Cunningham found the mesial fronto-Rolandic index to be 55·3, while in the chimpanzee it was 55·9. The orang gave an index of 55·5, so that in these two anthropoids the relative antero-posterior length of the upper part of the frontal lobe exceeds that of man. This does not, however, apply to the outer part of the frontal lobe, as Cunningham found the outer end of the fissure of Rolando relatively farther forwards in the chimpanzee and orang than in man. In the lower apes of the Old World the whole extent of the fissure of Rolando is farther forwards than in man. Although the frontal lobe is longer near the mesial plane in the chimpanzee and orang than in man, yet in both these anthropoids it is undoubtedly narrower, the anterior part of their brain being markedly pointed as compared with that of man. The vertical extent of the frontal lobe is also greatly diminished by the upward projection of the roof of the orbit. Taken as a whole, therefore, the frontal lobe is relatively much smaller in the anthropoids than in the human subject, and the diminution specially involves the outer part of the lobe. These facts, taken in connection with the discovery of Broca of the seat of articulate language in the inferior frontal convolution, lend a certain amount of probability to the contention of Bischoff and others that this convolution is either absent or very poorly represented in the apes. Gratiolet recognised in the brain of the apes superior middle and inferior frontal convolutions corresponding to those found in man, and Cunningham, after a very careful and elaborate investigation of the comparative and developmental anatomy of the frontal fissures, supports the conclusions of Gratiolet. In the New-World monkey, *Cebus albifrons*, the outer surface of the frontal lobe shows two fissures. One of these has a T-shaped form, its vertical limb dividing above into an anterior and a posterior branch. Eberstaller and Cunningham believe this to be the inferior prœcentral sulcus. The other fissure runs from the anterior end of the brain backwards towards the prœcentral sulcus, and ends below its anterior branch. This fissure, generally known as the gyrus rectus in the apes, is supposed by some to be absent in man; but Cunningham holds that this gyrus rectus represents the inferior frontal sulcus of man. The frontal fissures show a gradually increasing complexity as we advance from the lower to the higher forms of the Primate brain. According to Cunningham, the human frontal lobe is distinguished from that of the chimpanzee by the fact that its superior frontal convolution is generally divided into two parts by a sulcus-frontalis mesialis. This fissure, however, is absent or poorly developed in the brain of the Negro. Further, in man the inferior frontal convolution possesses two Sylvian opercula, a frontal and an orbital, both of which are completely absent in the anthropoids, so that in them a portion of the island of Reil is uncovered and exposed on the surface of the cerebrum.

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[1] Natural History Review, vol. i.

[2] Contribution to the Surface Anatomy of the Cerebral Hemispheres—Royal Irish Academy, Cunningham Memoirs, 1892.

Parietal Lobe.—According to Cunningham, "one of the leading peculiarities of the human brain is the relative great antero-posterior extent of the parietal lobe, and this is attained by a corresponding decrease in the length of the occipital lobe."

The parietal lobe in certain of the lower apes is traversed by a fissure which runs upwards and backwards, and divides the lobe into an antero-superior and a postero-inferior portion. This fissure is figured very distinctly in the brains of various apes by Gratiolet. In 1866 it was described and named intra-parietal by Sir Wm. Turner in an account of the brain of a chimpanzee, published in the *Proceedings of the Royal Society of Edinburgh.*

About the same time he recognised it as being present also in the human brain. In the same year, but a little later, Dr Adolf Pansch, of Kiel, independently described it under the name of sulcus parietalis. Many anatomists have since worked at this fissure, and it is now well established that, in the higher Primates, it is composed of at least four fissural elements, which Cunningham names sulcus verticalis superior, sulcus verticalis inferior, sulcus horizontalis, and sulcus occipitalis. Turner's original description of this fissure, in his paper on "The Convolutions of the Human Cerebrum topographically considered," is as follows:—

"*Intra-parietal Fissure.*—This fissure is figured in all the more accurate drawings of the human and quadrumanous brain, though no special description has been given of it. It lies within the parietal lobe, from which circumstance I have named it intra-parietal. It may be recognised by the sixth month of intra-uterine life. It is situated immediately behind and ascends parallel to the ascending parietal gyrus, and then bends almost horizontally backwards, and extends for a varying distance in different brains; in some cases it may be traced between the first and second bridging convolutions, as in the right hemisphere of figs. 1 and 2. Its ascending part separates the supra-marginal gyrus from the ascending parietal; its horizontal part separates the supra-marginal gyrus from the ascending parietal lobe. Not unfrequently one or more secondary gyri bridge it across superficially; a frequent seat for such a connecting convolution is at the angle of its ascending and horizontal portions, excellent representations of which may be seen in the brains of the Bushwoman, figured by Professors Gratiolet and Marshall." Sernoff and Cunningham have investigated the relation between the various elements composing the intra-parietal sulcus. It is interesting to note that, while in the majority of the apes these elements unite to form a fissure, such as Turner described, Cunningham found that in sixty-three adult Irish hemispheres it only occurred in 19·1 per cent. of the cases, while Sernoff found it even less frequently in adult Russian brains. Cunningham found the most common condition to be that in which the two portions of the vertical sulcus and the horizontal one were all united.

We do not as yet know sufficient regarding the development of the fissures in the brain of the apes to express a definite opinion, but it is very probable that various fissures, which in the human brain are developed from two or more separate elements which subsequently fuse, are formed in the apes from a single fissure. Thus it is now well known that the fissure of Rolando is developed in the human subject from two elements, a superior and an inferior. In the process of development they exhibit a very decided tendency to join, but occasionally we meet with a fissure of Rolando in the adult, composed of an upper and a lower part quite distinct from one another; and in the majority of human brains the fissure of Rolando will be found to be shallower at the point of union of the two original elements than above and below. The anthropoid apes will doubtless show a condition intermediate in this respect between man and such apes as the baboon and macaque.

The Island of Reil and its Opercula.—Many interesting points connected with the relative development of the brain in man and the apes are revealed by a study of the island of Reil and the portions of the cerebral cortex adjacent to it. It is well known that in the human brain, before the middle of fœtal life, the island of Reil lies fully exposed on the outer aspect of the undisturbed brain, while in the adult it is entirely concealed by the neighbouring portions of the frontal, parietal, and temporal lobes, which have grown more rapidly than the submerged island. The process of covering the island of Reil commences with the temporal lobe, which grows upwards and outwards, and meets a process from the parietal and adjacent portions of the frontal, passing outwards and downwards. These processes are known as the temporal and fronto-parietal opercula. By the end of the sixth month they have met, so as to conceal the posterior half of the island. About this time two other smaller opercula begin to appear, known as the frontal and orbital. The frontal operculum grows downwards and backwards, and the orbital directly backwards. The island of Reil is not fully concealed until about a month after birth, by which time the four opercula completely cover it. The lines corresponding to the meetings of the adjacent opercula form the three limbs of the Sylvian fissure; the anterior horizontal limb is between the orbital and frontal opercula, the anterior ascending limb between the frontal and fronto-parietal opercula, while the horizontal limb separates the temporal and fronto-parietal opercula. It was Broca who first pointed out the existence of two anterior limbs to the Sylvian fissure in man; indeed, he considered it as constant in the human subject, except in the case of imbeciles, idiots, and microcephalic individuals. Eberstaller, however, has shown that we may meet with all possible gradations from the single anterior limb to the Y, V, or U conditions. These variations depend upon the degree of development of the orbital operculum. If this be absent, only one limb is found; if only feebly developed, the single fissure is bifid at its extremity; while, if it be well formed, and grow downwards and backwards, so as to touch the temporal operculum, two distinct anterior limbs are present.

Broca and Hervé have described in the chimpanzee an anterior horizontal and an occasional anterior ascending limb to the Sylvian fissure, but Cunningham holds that in this they are mistaken, as in both these anthropoids there is a total absence of the frontal and orbital opercula, and consequently there can be no true anterior limb of the Sylvian fissure.

Although the island of Reil is entirely concealed in man, as already described, yet it is much more highly developed than in the apes. Cunningham figures it in the Chacma baboon as quite smooth. Waldeyer[1] found that in the gibbon it is nearly smooth, but generally shows a shallow sulcus centralis insulæ. In the chimpanzee, according to Cunningham, there are two oblique fissures dividing the insula into three convolutions, while in the orang there are three fissures and four convolutions.

In the human subject they are still more complex, and Eberstaller has shown that a remarkable correspondence exists between the fissures on the insula and those on the outer aspect of the rest of the hemisphere. Thus it is divided into an anterior and a posterior part by a fissure which has the same direction, and lies in the same plane of the fissure of Rolando. Guldberg has suggested for this fissure the very appropriate name of sulcus centralis insulæ. The island of Reil in front of this fissure shows three gyri which unite below to form the pole of the island. Eberstaller calls these three gyri from before backwards gyrus brevis primus, gyrus brevis secundus, and gyrus brevis tertius. Cunningham suggests for the gyrus brevis tertius the name gyrus centralis anterior, as this term would indicate its relation to the sulcus centralis insulæ and also associate it with the anterior central or ascending frontal convolution on the outer surface of the hemisphere.

Behind the central fissure of the island of Reil are two well-marked convolutions, separated by a fissure which may be called the sulcus post-centralis insulæ. This fissure corresponds to the vertical portions of the intra-parietal fissure.

I fear that I must have wearied you with these details, but I trust they have made clear to those not specially familiar with this department of anatomy the interesting fact, first enunciated by Leuret and Gratiolet, and abundantly confirmed by subsequent workers, that the arrangement of the cerebral fissures and convolutions in the anthropoid apes presents a striking resemblance to that of man, and that the higher anthropoid apes are less removed from man than from many of the lower Old World monkeys, such as the macacus or baboon.

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[1] Sylvische Furche und Reil'sche Insel des Genus Hylobates—Sitzungsber. der k. Preussischen Akad. des Wiss. Berlin, 1891.

It can readily be understood that the great advances in our knowledge of both the arrangement and functions of the cerebral cortex have led to numerous investigations regarding the topographical relations of the cerebral fissures and convolutions to the skull and scalp. These researches are of great practical importance to surgeons, as enabling them to cut down upon any particular convolution they may desire to examine, but they scarcely fall within the scope of this address. I would desire, however, to direct the attention of the members of the Society to some of the casts which have been prepared by Professor Cunningham in illustration of cerebral topography.

When we remember that, little more than fifty years ago, the conceptions of the position and relations of the cerebral fissures and convolutions were extremely vague and imperfect, while the physiology of the cortex was the subject of vague and generally erroneous speculations, we have good reason for congratulation at the present state of our knowledge of their anatomy and physiology.

I have dwelt more especially upon the anatomical aspects of this question, as being those with which I am more especially familiar; I trust, however, that it will not be supposed that I am wanting in appreciation of the work that has been accomplished by the physiologist.

No one nowadays ventures to question the utility of comparative anatomical investigations in extending and broadening our conceptions of the structure of the human body. As we have already shown, it is very largely by comparative anatomical investigations that we have been enabled to gain a sound morphological knowledge of the complex folds of the human cerebral cortex. Yet some would have us believe that in the sister science of physiology the comparative method is delusive and leads to no practical results. We are told with dogmatic emphasis and wearisome reiteration that experiments on animals are useless as throwing light upon the functions of the human body. I need not tell the Fellows of the Royal Physical Society that such a view of "man's place in nature" is absurd and unscientific. No unbiassed student of cerebral anatomy and physiology will deny the importance of such work as that of Hitzig and Fritsch, Ferrier, Munk, Gudden, Horsley, Schaefer, and Mott. Indeed, we may all rejoice that our recent advances in the anatomy and physiology of the cerebral cortex have led to such great advances in the diagnosis and treatment of its diseases.

I. *The Glacial Fauna of King Edward, in Banffshire.* By ALFRED BELL, Esq Communicated by JAMES BENNIE, Esq., H.M. Geological Survey.

(Read 21st December 1892.)

The sands and gravels that have yielded the organic remains noticed in this paper occur at an elevation of about 200 feet above the sea-level, in irregularly stratified beds of yellow and black clay, sometimes alternating with seams of fine sands, in the banks of a small burn near King Edward, about five miles from Banff.

The clay itself contains numerous glaciated stones and shell fragments, principally *Cyprina islandica*, and has been derived from the waste of the older Oxfordian clay, the characteristic ammonites being not infrequent. Clean sand yields the most perfect examples, these being fewest where crushed and broken débris attest the pressure the sands have undergone.

The fauna given up by these gravels is very remarkable, and appears to belong to the later stages of the period of intensest cold, many of the species occurring in the clays of Bridlington, in Yorkshire, in masses of transported sand introduced in a frozen state. The present habitats of the species recorded range from the confines of the Arctic Circle to the island of Jan Mayen and Spitzbergen, at an average depth of about 400 fathoms, the greatest depth given by Herman Friele in "Den Norske Nordhavs Expedition, 1876-1878," being 1861 fathoms.

The fauna, if not actually *in situ*, could not have come from any great distance, as so many of the species, especially the Naticas, abound from the fry to large and full-grown individuals. The Pleurotomas are equally plentiful. Whether the seventeen species quoted are all good may be doubtful; they are, however, sufficiently distinct, and are figured by such northern authorities as Sars and Friele, and may be permitted to stand. The calice of *Lophohelia prolifera* is the first recorded example of this coral in a fossil condition in Britain.

The veteran historian of the older eastern Scottish clays, Mr T. F. Jamieson, was, I believe, the first to call attention to the deposit. I have to thank the Rev. Dr John Milne, of King Edward, for assistance in many ways.

The deposit is well worth working, and would yield good results. The asterisk in the following list indicates that the shell has not been recorded as a Scottish fossil before—seventeen species out of fifty-seven being thus distinguished.

FOSSILS FROM THE KING EDWARD GRAVELS.

	ENGLISH LOCALITIES.
Astarte borealis, Chemn.	Common, except in south.
,, *compressa*, Mont.	Everywhere.
Cardium echinatum, L.	Common.
,, *edule*, L.	Everywhere.
,, *greenlandicum*, Chemn.	Red Crag, Suffolk; Bridlington; Oswestry; Worden, Lancs.
* ,, *islandicum* (?), L.	Bridlington; Worden.
Cyprina islandica, L.	Everywhere.
Cyamium minutum, Fabr.	Moderately common.
**Leda limata*, Say.	
,, *limatula*, Say.	Bridlington.
,, *lucida*, Lov.	
Mactra elliptica, Brown.	Common.
Mytilus edulis, L.	,,
Ostrea edulis, L.	,,
Pholas crispata, L.	,,
Saxicava rugosa, L.	,,
Tellina balthica, L.	,,
,, *calcarea*, Chemn.	,,
Aporrhais pespelecani, L.	,,
Buccinum undatum, L.	,,
Dentalium Tarentinum, Lam.	Not rare.
,, *entalis*.	Common.

Fusus antiquus, L.	Common, except on the coast.
,, *despectus*, L.	Bridlington.
,, *propinquus*, Ald.	Bridlington, and a few other places.
Lacuna divaricata, Fabr.	Common.
Littorina littorea, L.	Everywhere.
Nassa incrassata, Ström.	Common.
**Natica alderi*, E. F.	Not rare.
,, *affinis*, Gmel.	Everywhere but the south.
,, *greenlandica*, Beck.	Not rare.
,, *islandica*, Gmel.	Bridlington, Kelsey Hill, and March, Cambs.
**Pleurotoma bicarinata*, Couth.	Newer Red Crag, Suffolk.
* ,, *cinerea*, Möll.	Bridlington.
* ,, *elegans*, Möll.	,,
* ,, *harpularia*, Couth.	Chillesford clay beds.
* ,, ,, var. *robusta*, S. V. Wood.	Bridlington.
* ,, *nobilis*, Möll.	New to Britain.
,, *pyramidalis*, Ström.	Common, except in the south.
* ,, *scalaris*, Möll.	Bridlington.
* ,, ,, var. *abyssicola*, Friele.	New to Britain.
* ,, ,, var. *ecarinata*, Sars.	,, ,,
* ,, *scalaroides*, Sars.	,, ,,
,, *Trevelyana*, Turt.	Moderately common, except in the south.
,, *turricula*, Mont.	Everywhere.
**Defrancea simplex*, Midd.	Bridlington.
,, *violacea*, Migh.	,,
* ,, *viridula*, Möll.	Not known.
Scalaria greenlandica, Chemn.	Moderately common.
Trophon clathratus, L.	
,, ,, var. *Gunneri*, Lov.	,, ,,
,, *truncatus*, Ström.	
Turritella polaris, Beck.	Bridlington.
* ,, *reticulata*, Migh.	New to Britain.
,, *terebra*, L.	Common.
Portunus corrugatus.	
**Lophohelia prolifera.*	Unique.

II. *On a Deposit in Largo Bay.* By ALFRED BELL, Esq. Communicated by JAMES BENNIE, Esq., H.M. Geological Survey.

(Read 21st December 1892.)

Since the publication, in Vol. X., *Proc. Roy. Phys. Soc. Edin.*, of a paper upon the deposit in Largo Bay, I have re-examined some of the floatings, and obtained some additions to the fauna, including a single valve of a species of *Montacuta* or *Sphenalia* which appears to be the same as *M. truncata*, Wood, a somewhat scarce form in the Suffolk Crag, and the Pliocene clay at St Erth, in Cornwall, in which I have seen one or two examples, and ranging back in time to the Miocenes of the Vienna basin. Like *M. donacina*, also a Crag shell, of which a few recent valves have been dredged off the Shetland Islands, it is probably a scarce inhabitant in the North Sea, but as yet undiscovered in a recent state.

From this same locality I have also a single example of an Odostomia-like shell that does not appear to be British, neither can I trace it as a recent species; it comes near to a St Erth shell which I have described as *Eulimene acuminata*. This specimen is broad at the periphery, pointedly acute to the apex, and the base of the shell prolonged into a sharp spatulous beak.

Chemnitzia clathrata, of which three or four were picked out, does not occur living nearer than the west of Ireland, but is a Suffolk Crag, and St Erth fossil.

The varieties *terebellum* and *suturalis* of *Od. interstincta* are more southern than northern shells. The latter is an English Pliocene fossil, and occurs recent in the Firth of Clyde and elsewhere in the west. The var. *terebellum* is almost entirely confined in its range to the south-west of England and to the Mediterranean.

Chiton asellus, Chemn.
,, *fascicularis*, L.
Trochus umbilicatus, Mont.
Lacuna patula, F. & H.
Rissoa costata, Don.
,, *inconspicua*, Ald.
,, ,, var. *albula*, E. F.
,, *semistriata*, Mont.
,, *soluta*, Phil.
,, *proxima*, Ald.
Hydrobia ventrosa, Mont.
Eulimene acuminata, A. Bell.
Aclis ascaris, Turt.
,, *supranitida*, S. V. Wood.
Eulimella scillae, Scac.
Chemnitzia interstincta, Mont.
,, ,, var. *terebellum*, Phil.
Chemnitzia interstincta, var. *suturatis*, Phil.
,, *clathrata*, Jeffr.
Odostomia unidentata, Mont.
,, *pallida*, Mont.
,, *Warreni*, Thomp.
Pleurotoma costata, var. *Metcalfei*.
,, *striolata*, Phil.
,, *septangularis*, Mont.
,, *Trevelyana*, Turt.
Mytilus phaseolinus, Phil.
Crenella decussata, Mont.
Montacuta truncata, S. V. Wood.
Cyamium minutum, Fabr.
Cardium nodosum, Turt.
,, *suecicum*, Lov.
Circe minima, Mont.
And a Crab, *Cancer pagurus*.

So many of these are either so rare, or else unknown in the recent eastern seas of Scotland, that it seems feasible to suppose that some alteration has ensued since these deposits were laid down.

Since the paper on Largo Bay was read, I have been made acquainted with a very interesting notice of "The Raised Sea-Bottom of Fillyside," on the opposite side of the Firth to Largo, and, after careful comparison of the faunas of each locality, am disposed to consider them as nearly of the same age, the facies of the two being very similar; and this would probably be more apparent if a larger series of the shells were examined, so many having been listed from single examples.

A combination of the Largo and Fillyside species shows, upon analysis, that of the 155 molluscs—

46 species are common to both deposits,
89 „ have only been found at Largo,
20 „ „ „ „ Fillyside,
155

and that, out of these 155 species, only 52 have been obtained out of the various post-Glacial fossiliferous deposits of the east coasts from the earliest to the latest developments, including Elie, King Edward, and Caithness; and, if the latter had been eliminated, the numbers would have been even less.

Excluding all reference to the earlier Pliocene, the appended list shows that 16 species do not occur (or have not been recorded) in any other post-Pliocene deposit in the three kingdoms, that 34 species have their nearest geological homes either at Kelsey Hill or Bridlington in Yorkshire, Selsey in Sussex, in the Lancashire drifts, the Belfast Estuarine Clays, or the Portrush accumulation, and the remaining 53 are common to the clays and other strata in the western side of Scotland, chiefly in the line of the Clyde.

It can hardly be that these two deposits are unique in East Scotland, and now that the labours of Mr Bennie have opened up such a fruitful field for investigation, the results being so interesting up to the present, it is to be hoped that these apparently insignificant deposits may receive the attention they deserve. The continual waste of the coast-line, and the unpromising nature of the strata on the east side of England, are unfavourable to the preservation of post-Glacial raised sea-bottoms, if such ever existed.

Not known in any other post-Pliocene deposit in the United Kingdom.

Aclis ascaris.
Cæcum glabrum.
Cylichna umbilicata.
Eulimella scillae.
Eulimene acuminata.
Lacuna patula.
Odostomia clavula.
,, *obliqua.*
Odostomia truncatula.
,, *umbilicatula.*
,, *Warreni.*
Pilidium fulvum.
Pleurotoma striolata, var. *Metcalfei.*
Rissoa abyssicola.
,, *proxima* (?).
Montacuta truncata.

Not known in a fossil state elsewhere in Scotland, the nearest localities being—*Loc.* B(elfast), Br(idlington), K(elsey) H(ill), S(elsey) in Sussex, L(ancashire).

Cardium nodosum, B., S.
,, *suecicum*,[1] S.
Diplodonta rotundata, S., L.
Lasea rubra, B., S.
Loripes lacteus, S.
Mactra stultorum, L.
Modiolaria marmorata, B., S.
Panopea fragilis, B., S.
Pholas candida, S., L.
Solen siliqua, B., L.
Syndosmya tenuis, S.
Aclis unica, S.
,, *supranitida*, B., L.
Adeorbis subcarinatus, S., Torbay, Portrush.
Barleeia rubra, Portrush.
Chemnitzia lactea, B.
Chemnitzia rufa, S.
,, *clathrata*, S.
,, *interstincta*, S.
,, ,, vars., S.
Nassa reticulata, K.H.
Odostomia acuta, S., B.
,, *interstincta*, B.
,, *plicata*, B., S.
,, *pallida*, B.
,, *scalaris*, S.
Philine nitida, S.
Rissoa albella, B.
,, *costata*, B., Br.
,, *semistriata*, Br., B.
,, *soluta*, S.
,, *vitrea*, B.
,, *zetlandica*, Portrush.

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[1] Said to occur at Bute, Jeffr., *fide* Wienkauff.

Common to West Scotland, but not to the eastern coast except Largo or Fillyside.

Axinus flexuosus.
Corbula gibba.
Lepton nitidum.
Lutraria elliptica.
Montacuta bidentata.
,, *ferruginosa.*
Mytilus phaseolinus.
Nucula nitida.
,, *nucleus.*
Psammobia ferroensis.
Syndosmya alba.
Tapes pullastra.
,, *virginea.*
Tellina fabula.
Thracia papyracea.
Venus fasciata.
,, *striatula.*
Amphisphyra hyalina.
Chiton cinereus.
,, *asellus.*
,, *fascicularis.*
Helcion pellucidum.
Homalogyra atomus.
Hydrobia ulvæ.
,, *ventrosa.*
Lacuna pallidula.
,, *patula.*
Littorina rudis.
,, *saxatilis.*
,, *tenebrosa.*
Murex erinaceus.
Natica catena.
Odostomia conoidea.
,, *spiralis.*
,, *turrita.*
,, *unidentata.*
Patella vulgata.
Philine aperta.
Pleurotoma costata.
,, *striolata.*
Rissoa inconspicua.
,, ,, var. *albula.*
,, *membranacea.*
,, *parva.*
,, *reticulata.*
,, *striata.*
,, *violacea.*
Skenea planorbis.
Trochus cinerarius.
,, *helicinus.*
,, *umbilicatus.*
Utriculus Lajonkairii.
,, *truncatulus.*

III. *The Raised Sea-Bottom of Fillyside.* By James Bennie, Esq., H.M. Geological Survey. *With Lists of the Foraminifera and Ostracoda.* By David Robertson, Esq., F.L.S.

(Read 15th February 1893.)

These Foraminifera and Ostracoda were determined by Mr David Robertson, F.L.S., in 1872, from portions of sand and mud obtained from the raised sea-bottom at Fillyside, and which I sent to him at that time. These lists ought to have been included in the paper of last session, but, unfortunately, I had forgotten the circumstance, and only found it out while referring to my letters for that year, wherein I found Mr Robertson telling me he had got twenty species of Foraminifera and twenty-five species of Ostracoda from the material lately sent to him.

On becoming aware of this forgotten fact, I wrote to Mr Robertson, asking if he would give me the lists for publication in the next part of our *Proceedings*. He kindly consented, and forwarded the lists which I have now the pleasure of laying before the Society.

FORAMINIFERA.

Family MILIOLIDÆ.

Subfamily MILIOLININÆ.

Biloculina elongata, D'Orb.
Miliolina oblonga, Mont.
„ *contorta*, D'Orb.
„ *secans*, D'Orb.
„ *angulata*, Kerrer.
„ *subrotunda*, Mont.
„ *circularis*, Borneman.

Subfamily HAUERININÆ.

Ophthalmidium inconstans (?), Brady.

Subfamily PENEROPLIDINÆ.

Cornuspira involvens, Reuss.

Subfamily TROCHAMMININÆ.

Trochammina ochracea, Williamson.

Subfamily LAGENINÆ.

Lagena Williamsoni, Alcock.
„ *squamosa*, Mont.
„ *sulcata*, Walker and Jacob.

Subfamily POLYMORPHININÆ.

Polymorphina Gibba, D'Orb.

Subfamily ROTALINÆ.

Discorbina globularis, D'Orb.
Truncatulina lobatula, Walker and Jacob.
Rotalia beccarii, Linné.

Subfamily POLYSTOMELLINÆ.

Nonionina depressula, Walker and Jacob.
Polystomella crispa, Linné.
„ *striatopunctata*, Fichtel and Moll.

OSTRACODA.

Family CYTHERIDÆ.

Cythere lutea, Müller.
„ *pellucida*, Baird.
„ *porcellanea*, Brady.
„ *confusa*, Brady and Norman.
„ *crispata*, Brady.
„ *albomaculata*, Baird.
„ *convexa*, Baird.
„ *villosa*, G. O. Sars.
„ *pulchella*, Brady.
„ *angulata*, G. O. Sars.
Cytheridea elongata, Brady.
„ *papillosa*, Bosquet.
Eucythere declivis, Norman.
Loxoconcha guttata, Norman.
„ *tamarindus*, Jones.
Xestoleberis aurantia, Baird.
Cytherura striata, G. O. Sars.
„ *angulata*, Brady.
„ *undata*, G. O. Sars.
„ *nigrescens*, Baird.
„ *cellulosa*, Norman.
Sclerochilus contortus, Norman.
Cytherois fischeri, G. O. Sars.

Family PARADOXOSTOMATIDÆ.

Paradoxostoma variabile, Baird.
„ *abbreviatum*, G. O. Sars.

IV. *On the Identity of the* Rubecola Tytleri *of Jameson.* By Wm. Eagle Clarke, F.L.S., M.B.O.U.

(Read 15th February 1893.)

At a meeting of the Wernerian Society, on the 25th of April 1835, Professor Jameson exhibited and described what he believed to be a new species of bird, to which he gave the name of *Rubecola Tytleri.* Of this species no adequate description appears to have been published. In the *Memoirs of the Wernerian Society* (vol. vii., p. 487), and in the *Edinburgh New Philosophical Journal* (vol. xix., p. 214), however, there appeared, in identical terms in both publications, an account of the "Proceedings" of this meeting. In these the new bird is shortly described as agreeing "in the grouping of the colours with the common Robin; yet, in the form of the bill, it presented, as it were, a link between the genus *Rubecola* and *Phœnicura*"—that is, between the Robin and the Redstart. The specimen is also described as having been sent to the Edinburgh University Museum by Lieut. Tytler "from the Himalayan Mountains."

This description, though very slight, is sufficient to indicate that *Rubecola Tytleri* belongs to a small group of Flycatchers of the genus *Muscicapa,* the males of which are red-breasted, and which, chiefly from the style of their coloration, were promoted by Prince Bonaparte to the rank of a genus—*Erythrosterna.* As to which particular species of the group this bird should be assigned, some uncertainty has always prevailed. If this had not been so, and if it had not been awarded synonymic rank in several works of importance, and if too, it had not been, as I am now able to state, associated with the wrong species, then *Rubecola Tytleri* might have been allowed to remain in the shades of obscurity in which Professor Jameson left it.

Under the circumstances, however, it was, perhaps, not undesirable that the type-specimen should be forthcoming While recently engaged in rearranging the Bird Collections in the Edinburgh Museum of Science and Art, I came across Professor Jameson's type-specimen of this bird, with the original endorsement still on the stand. An examination of the specimen leaves no room for doubt that it is an old male of *Muscicapa parva*, Bechstein, and that it is not referable to *Muscicapa albicilla*, Pallas (= *M. leucura*, Gmelin), with which it has hitherto, though doubtfully, been associated.

Muscicapa parva is, however, only a winter visitor to the plains of the Indian peninsula and China, spending the summer in Turkestan and southern Siberia. It is also a summer bird in central and south-eastern Europe, being fairly common, but local, in north-eastern Germany and central and southern Russia, and farther east in the Caucasus and northern Persia. The winter range of the European birds extends to Nubia; and it may, perhaps, occur irregularly at that season in southern Spain.

Since Professor Jameson's days the Red-breasted Flycatcher has become a member of the British avifauna, inasmuch as it has occurred as a rare straggler in England and Ireland in the autumn and winter, being first recorded in the year 1863.

One more point remains for notice regarding this bird, namely, that in synonomy it is usually quoted as *Erythaca Tytleri*. I am not aware that Professor Jameson ever applied the generic name of *Erythaca* to his species.

It may be of interest to note, that in the latest work published on the avifauna of India, Mr Oates ("Fauna of British India," Birds, ii., p. 9) remarks that he has not seen an example of *Siphia* (= *Muscicapa*) *parva* from any portion of the Himalayas.

V. *Some New or Little Known Oligochæta.* By Frank E. Beddard, M.A., F.R.SS.L. & E., Prosector to the Zoological Society of London.

(Read 15th March 1893.)

I propose in the present paper to offer to the Royal Physical Society some notes which I have gathered together during the last few years upon Oligochæta from various parts of the world. I describe three new species and give some additional notes upon two others, of which one has been incompletely described by Dr Michaelsen, while the other is well known. I am able, however, in the present paper to record a wider distribution. The species that I deal with now are the following:—

1. *Pontodrilus hesperidum*, n. sp.
2. *Microscolex novæ zelandiæ*, n. sp.
3. *Fridericia antarctica*, n. sp.
4. *Henlea ventriculosa*, d'Udek.
5. *Cryptodrilus spatulifer*, Mich.

I. Cryptodrilus spatulifer, Mich.

Cryptodrilus (?) spatulifer, W. Michaelsen, Jb. Hamb. wiss. Anst., vi.

I have examined a single specimen of a worm which I refer to this species in spite of a few discrepancies between my own observations and Michaelsen's statements.

The specimen was collected some few years ago by Mr Lane, who was sent out by the late Mr Berkeley James to Chili for the purpose of collecting birds.

The *colour* of the preserved specimen was, as Michaelsen has remarked, of a dark purple-red dorsally; it measured 60 mm., and consisted of 93 segments.

The *prostomium*, however, is different from that as described by Michaelsen; in the worm examined by myself it was complete, *i.e.*, it completely divided the buccal segment, reaching as far as the boundary line between this segment and the one behind.

The *setæ* are strictly paired, and are visible on all the segments of the clitellum.

The *clitellum* extended from the xiiith to the xvith segment.

The *nephridiopores* open in front of the dorsal pair of setæ.

The *male pores* are upon the xviith segment.

There is a *gizzard* in segment vi.; the *intestine* begins in segment xvii. or perhaps in xviii.; after the xviith segment it gradually increases in calibre until a little way after the beginning of the xviiith segment.

The first *septum* divided segments vi./vii.

The *testes* seem to be present to the number of a single pair only; in any case I could only discover a single pair of funnels in segment x. As there was only a single pair of sperm sacs—racemose in character—in segment xi., there is an increased probability of the presence of only a single pair of testes. Michaelsen did not observe the testes or sperm sacs or funnels.

The *atria* are lobate, they resemble in fact those of *Perichæta;* they are very solid in appearance, not being of the loose texture often seen in *Perichæta.* Michaelsen is somewhat indefinite about the structure of the atria; he describes them as "zwei lange kolbige Prostata-drüsen." These open on to the xviith segment; they are provided with *penial setæ.* There is no need for me to give any description of the penial setæ, since my observations agree fully with those of Michaelsen.

There is but one pair of *spermatothecæ;* these are large, and lie in segment ix. Each consists of a pouch, which is somewhat bifid, and which communicates with the exterior by means of a thick-walled duct; into this opens a diverticulum, which is as long as the pouch. It also consists of a duct and a distal swollen end, which is mulberry shaped. The diverticulum lies in the segment in front of that which contains the pouch, as is so often the case in earthworms.

The only difference of importance between the above description and that of Michaelsen is in the prostomium; it is possible that imperfect preservation may account for this. The close similarity in the penial setæ, and the fact that there is but one pair of spermatothecæ, seems to remove all doubt as to the identity of the species described by myself with that described by Michaelsen. It is, however, doubtful whether the worm should be referred to the genus *Cryptodrilus.* The principal objection to including it in that genus is the position of the male pores; in *Cryptodrilus* they are on segment xviii. If other species turn up in which the male pores are upon the same segment, and which have lobate atria, I should separate them as a distinct genus; at present a single instance of a divergence in the position of the male pores may be fairly regarded as an exception, and the worm may be left in the genus to which Michaelsen doubtfully assigned it. The specimen was collected in Valdivia.

II. Microscolex nova zelandiæ, n. sp.

Length, 42 mm.; *breadth*, 2 mm.; *number of segments*, 76.

The *prostomium* is continued over about half of the buccal segment.

The *clitellum* extends over segments xiii.-xvii., and is complete save for a small ventral tract posteriorly. The clitellum is marked posteriorly by a triangular notch having the form and extent shown in the accompanying illustration (Fig. 1), which is occupied by the male genital pores and by certain papillæ. The *male pores* are small orifices with an obvious and thick chitinous lining. They are situated about half way from either end of the layer of unmodified epidermis, which here invades the clitellum close to its margin. They are exactly on a line with the innermost seta of the ventral pair. These setæ, as already mentioned, are absent from the xviith segment which bears these pores. In front of the male pores is a single median *papilla;* behind them are a pair of similar papilla, which lie somewhat to the inside of the male pores. The seta are in four series of pairs, the individual setæ of each pair being not very close together. They are unornamented.

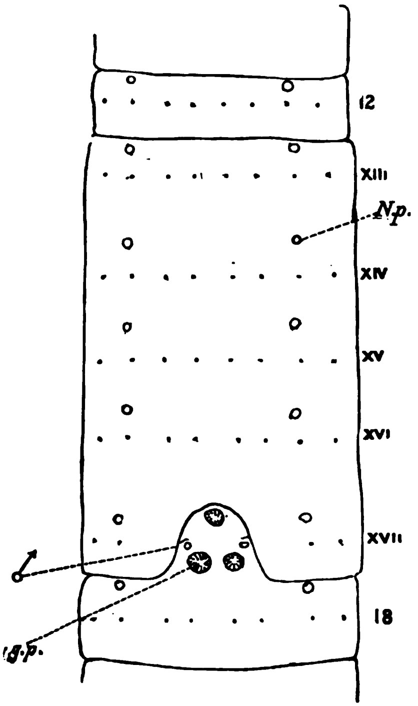

Fig. 1.
Ventral view of segments in neighbourhood of genital orifices. The clitellar segments are numbered with Roman numerals; *N.p.*, nephridiopores; ♂, male pores; *g.p.*, genital papillæ.

The *nephridiopores* are in front of seta 3.

The *nephridia* of this worm are paired organs. From and including the second segment of the body, the nephridia open by a large muscular sac. This sac appears to be capable of contraction and expansion, as in the nephridia of some segments the lumen was almost obliterated; in others, on the contrary, it was very spacious. In the case of the nephridia of the ivth segment, the terminal sac was greatly reduced, and the external aperture (in longitudinal sections) in consequence very inconspicuous. Nephridia are present in all the genital segments.

The *dorsal vessel* is single. In segments x., xi., xii. are dilated *hearts.* In the intestinal region the dorsal vessel gives off in each segment two pairs of branches, which supply the intestine; the dorsal vessel is here clothed with a layer of peritoneal cells, which are also continued on to its branches. Like those covering the intestine, they are vesicular in appearance and but little stained. I observed no subneural vessel.

The *alimentary canal* is entirely *without gizzard or calciferous glands*—a state of affairs commonly met with in small, often aquatic, Oligochæta, whose nearest relatives are comparatively large terrestrial forms. The same is the case, to quote one example from several, with *Pontodrilus*, a near ally of the present species. *Pontodrilus*, however, is not always so destitute of a gizzard as is the worm which forms the subject of the present communication. In *Pontodrilus littoralis* the muscular wall of the œsophagus is thicker in one particular region than it is elsewhere. In *Microscolex novæ zelandiæ* the longitudinal muscular layer of the œsophagus in segment v. is rather more pronounced than in any other part of the œsophagus; this region is also wider, and it seems undoubtedly to represent the gizzard of other forms. As, however, the epithelium which lines this part of the œsophagus does not differ in appearance from that which lines the rest of the tube, and as there is no chitinous layer thrown off by this epithelium, this part of the œsophagus cannot be termed a gizzard. In segments xi., xii., and xiii. the œsophagus is widened out in each segment, but constricted where it passes through the septa. The intestine begins in segment xvi. It has the merest trace of a typhlosole in the shape of a convexity just below the dorsal vessel.

None of the intersegmental *septa* of this worm are very greatly thickened. Those separating segments viii./ix., ix./x., x./xi., xi./xii., xii./xiii. are somewhat thicker than those which follow or precede them. The septal glands are found as far back as in the viith segment.

The *testes* and the *sperm duct funnels*, of which there are two pairs, lie in segments x., xi. The *sperm sacs* are also two pairs, occupying segments xi., xii. The two sperm ducts of each side pass side by side along the body wall to the neighbourhood of the atrial pore; they pass to the distal side of the muscular duct of the atrium, and penetrate the body wall close together, but independently of each other and of the atrial duct. The two sperm ducts then become one; in longitudinal sections through this region of the body, three tubes can be seen in section forming together a triangle, of which the apex is nearest to the lateral margin of the body. The apex is formed by the atrium; anteriorly is the penial seta sac and posteriorly the sperm duct; all three tubes are of approximately the same calibre. They finally open on to the exterior by a common pore.

The *ovaries* lie in the xiiith segment. Opposite to them are the oviducts, which open externally on to the xivth. There are no egg sacs.

The *atria* are tubular, as in many other Cryptodrilidæ. They are short, not extending far back from the point of opening on to the exterior; this, as has been mentioned in describing the external characters, lies in the xviith segment. The atria reach back to the end of the xviiith segment. As is usual, the atrium is partly glandular and partly muscular; it is in fact constructed upon the plan which characterises *Acanthodrilus* and other genera with tubular atria. The sac of *penial setæ*, to which reference has been already made in describing the sperm duct, contains two or three setæ. These are longer than the ordinary setæ, but in some instances at anyrate have the same S-shaped curvature. The free extremity, moreover, is not ornamented.

There is only a single pair of *spermatotheca*. These lie in the ixth segment, and open on to the internal viii./ix. Each has two diverticula, one directed forwards and the other backwards. They arise of course from opposite sides of the duct of the spermatotheca.

The arrangement of the species belonging to the family Cryptodrilidæ is not by any means easy. This is doubtless partly due to imperfect knowledge. Fletcher,[1] for example, has not always described in a manner sufficiently clear the characters of the atria, which I believe to be of some importance in the grouping of the species. The species placed by him and by Spencer[2] in the genera *Megascolides* and *Cryptodrilus* evidently require some rearrangement. I do not, however, propose to offer here any amendments as far as concerns those genera. *Rhododrilus*[3] differs principally in that the male pores are upon the xviith instead of the xviiith segment. It evidently comes near to *Microscolex*. The description of the new species seems to me to reduce the distance to such infinitesimal proportions that *Rhododrilus* must be merged in *Microscolex*. I defined[4] *Microscolex* in terms which must now be slightly altered so as to include *Rhododrilus minutus*. The amended definition may run thus:—

MICROSCOLEX, Rosa.

Microscolex, D. Rosa, Boll. Mus. Torino, vol. ii., No. 19.
Rhododrilus, F. E. Beddard, P.Z.S., 1889, p. 380.

Setæ eight per segment. Clitellum xiii. (xiv.)–xvi. (xvii.), complete ♂ pores on xvii. No dorsal pores. Alimentary canal with or without gizzard, without calciferous glands; no typhlosole. Nephridia paired, commencing in one of segments ii.-v. Atria tubular, with or without penial setæ; spermatotheca one or four pairs, with a diverticulum.

Distribution.—Italy, Madeira, Algeria, Argentine, Australia, New Zealand.

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[1] In his series of papers upon Australian Earthworms in the Proceedings of the Linnean Society of New South Wales.

[2] Proc. Roy. Soc. Vict., 1892.

[3] F. E. Beddard, On the Oligochætous Fauna of New Zealand, etc.—P.Z.S., 1889, p. 380.

[4] On the Earthworms collected in Algeria and Tunisia by Dr Anderson—P.Z.S., 1892, p. 36.

III. Pontodrilus hesperidum, n. sp.

The large and important family Cryptodrilidæ has, so far as we know at present, very few representatives in the New World. Besides several species of *Ocnerodrilus* and *Microscolex*, the former of which is certainly, the latter probably, indigenous to that part of the world, the following species only have been recorded from America and the West Indies:—

Cryptodrilus spatulifer, Mich., Chili.
Gordiodrilus dominicensis, F. E. B. Dominica.
Plutellus heteroporus, Perr. Pennsylvania.
„ *perrieri*, Benh. British Columbia.
Pontodrilus arenae, Mich, (= *P. bermudensis*, F. E. B.). Bermudas.

I have therefore less hesitation in giving a somewhat imperfect description of a new species from Jamaica, which is certainly not identical with any of the above. The single specimen which I had at my disposal is immature.

The single specimen of this worm was of small size, an inch or so in length, and not more than 1·5 mm. in diameter. The specimen being immature, there was no clitellum visible.

The *setæ* are paired, but the individual setæ of each pair are at some distance from each other. On the xviiith segment the outermost of the two ventral setæ is absent, its place being occupied by the male reproductive pores. The oviducts open a little to the inside of the ventral setæ on each side.

Considering the small size of the worm, the thickness of some of the anterior septa is not a little remarkable. The present species is hardly larger than *Rhododrilus parkeri*, but those septa that are thickened are enormously more so. It must be recollected, however, that the present is apparently purely terrestrial in habit, and it cannot be doubted that there is some relation between the thickness of the septa and the terrestrial habit. There are eight thickened septa, the last of which divide segments xii./xiii. Of these the 5th, 6th, and 7th are decidedly stouter than the rest. There is one delicate septum in front of the first thickened septum, which therefore bounds segments iv./v. The middle septa of the series are quite twice as thick as the body wall in their immediate neighbourhood.

The *alimentary canal* is chiefly remarkable for the total absence of gizzard and calciferous glands. Almost immediately after it leaves the pharynx, the œsophagus widens out; in the viith segment it narrows; it is again dilated in the xith and xiith segments. The intestine begins in the xvth segment.

In the anterior segments of the body there are quantities of floating corpuscles.

The *nephridia* are paired structures, but are not furnished with a large end sac; the absence of this has prevented me from discovering the external pore.

The *hearts* are large and very conspicuous in longitudinal sections. There are valves where they open into the ventral vessel, but apparently not along their course. The last pair of them are in segment xiii. The first pair, showing a specially enlarged condition, are farther forward than is usual, viz., in segment ix. Underneath the intestine and œsophagus is a vessel which receives blood from its walls and has the same relation to it thus far below that the supraintestinal has above; I have not made out its relations, if any, to the other longitudinal trunks; it seems to correspond to the lateral vessels of other earthworms.

The *testes* are two pairs, lying attached to the anterior circle of segments x., xi.; each is broader at the base and tapers towards its free extremity. Opposite to the testes are the funnels of the sperm ducts. The two sperm ducts of each side of the body fuse early to form a single tube, which seemed to me to be of unusual thinness; it runs in the somewhat thick layer of peritoneum which covers the ventral body wall towards the xviiith segment. It opens into the atrium at some little distance from the external aperture of the latter. The atrium has the tubular form found in so many Cryptodrilidæ; it is also, as is usually the case, divisible into a glandular and a muscular section; the glandular part lies chiefly in segments xviii. and xix. A number of muscular strands are attached to the integument just at the aperture of the atrium, which they doubtless serve to protrude and retract. There are no *penial setæ*. The *atrium* is lined throughout by a single layer of cells, which are taller and narrower away from the external pore. A thick layer of tissue of fibrous appearance, with nuclei and interspersed blood-vessels, surrounds the lining epithelium. I do not at present lay any stress upon the fact that the atrium is lined by a single layer of cells only. The fact is, of course, very important if it really characterises the species, and is not due to immaturity.

The racemose *sperm sacs* hang from the anterior septa of segments xi., xii. The *ovaries* are in xiii.; the oviducts open opposite to them and on to the exterior in segment xiv. There were no egg sacs.

There are two pairs of *spermatothecæ*, placed respectively in segments viii. and ix. They are probably not fully mature, though of fair size; each is an oval pouch with a single cylindrical diverticulum.

The above description, necessarily incomplete though it is in several particulars, leads me to place this species in the genus *Pontodrilus*. At present this genus is only known by two species; the type species is, of course, *Pontodrilus littoralis* of Grube,[1] which is probably the same as Perrier's [2] *Pontodrilus marionis*. More recently the genus has been shown to inhabit the New World by Michaelsen and by myself. Michaelsen[3] described a second species of the genus under the name of *Pontodrilus arenae*, which species is identical with that called by myself *Pontodrilus bermudensis*.[4] I am inclined, moreover, to refer to the same genus Giard's species[5] *Photodrilus phosphoreus*. Rosa[6] has called attention to the great similarity that exists between the two genera;

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[1] Ueber neue oder wenig bekannten Anneliden—Arch. f. Nat., Bd. xli., p. 127.

[2] Etudes sur l'organisation des Lombriciens terrestres: iv. Organisation des *Pontodrilus* (E. P.)—Arch. Zool. Exp., t. ix., p. 175.

[3] Terricolen der Berliner Zoologischen Sammlung, ii.—Arch. f. Nat., 1892, p. 14.

[4] Abstract of some Investigations into the Structure of the Oligochæta—Ann. Mag. Nat. Hist., Jan. 1891, p. 96.

[5] Sur un nouveau genre, etc.—Compt. Rend., 1887.

[6] Sui Generi *Pontodrilus*, *Microscolex*, e *Photodrilus*—Boll. Mus. Tor., V. iii.

they agree in the form of the atria, in the fact that the nephridia do not commence until the xiiith or xivth segment, in the absence or rudimentary condition of the gizzard, in the absence of penial setæ at the male pore, which is in both upon the xviiith segment, and in a number of minor points.

I believe that it is necessary to add a fifth species to the four above enumerated; this is *Cryptodrilus insularis* of Rosa.[1]

Although the species is referred by Rosa to the genus *Cryptodrilus*, this is only done provisionally. As Rosa justly remarks, the genera of this family require revision.

I place *Cryptodrilus insularis* in the genus *Pontodrilus* for the following reasons:—It has

1. Setæ in eight rows.
2. No dorsal pores.
3. Rudimentary gizzard.
4. No nephridia until the xiiith segment.
5. Tubular atria, and no penial setæ.

This assemblage of characters distinguishes the genus *Pontodrilus* from any other genus; it comes nearest, of course, to the genus *Megascolides;* but differs in the fact that the nephridia do not commence at once (*i.e.*, in the iind or iiird segment). In the same point it differs from the genus *Microscolex.* It is true that the difference may not appear to be a very great one; but it is, considering the very large number of Cryptodrilids, and their similarity to each other, a good deal to have got one character running through a number of species, which also agree in other particulars. The five species may be thus distinguished:—

Setæ ornamented.	*P. arenae.*
Setæ not ornamented.	
Gizzard completely absent.	
Two pairs of spermatothecæ.	*P. hesperidum.*
One pair of spermatothecæ.	*P. phosphoreus.*
Gizzard rudimentary.	
Setæ irregular behind.	*P. insularis.*
Setæ regular throughout.	*P. littoralis.*

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[1] Die exotischen Terricolen des k. k. naturhist., etc.—Ann. k. k. nat. Hofmus., Bd. vi., 387.

SOME NEW ZEALAND ENCHYTRÆIDÆ.

I am indebted to Mr W. W. Smith for two tubes containing Enchytræids. The only record, so far as I am aware, of the existence of this family in New Zealand is a mere notice by myself contained in a paper upon the development of an earthworm. I am now for the first time able to describe more accurately the species which are met with in New Zealand,—those forwarded to me by Mr Smith were sexually mature. One of these species proves to be new, and is described below as *Fridericia antarctica;* the other is the well-known *Henlea ventriculosa.* The latter was collected at the edge of a swamp near the Tengawai river, South Canterbury. I have been able to make sure that it is the species mentioned above, as I have been able, through the kindness of Dr Michaelsen, to examine specimens identified by him as *Henlea ventriculosa.* So many writers have dealt with the structure of this Enchytræid, including Dr Michaelsen himself, that I have not found myself able to add anything to our knowledge of its anatomy. I can confirm, especially with regard to the salivary glands, Dr Michaelsen's statements. I received a few years since, through the kindness of Mr Bateson, examples of this same worm which he collected in his expedition to the territory of the Khirgese Tartars. The species has therefore a very wide range.

IV. Fridericia antarctica.

Of this species I have examined a number of examples collected at the edge of a spring near Ashburton, New Zealand.

The *colour* of the worm during life is stated to have been a "pale pink." It is a long thin Enchytræid, consisting of 46-63 segments. The following figures relate to three specimens which I selected for measurement and external description:—

	Length.	Number of Segments.
A.	18 mm.	63
B.	15 mm.	47
C.	16 mm.	45

The *setæ* are 4-6 in each bundle, generally 4 or 6, occasionally 5. The innermost pair were, as is usual with this genus, very much smaller than the setæ on either side of them. In the last five or six segments of the body there were only a pair of setæ to each bundle. As many as six setæ in a bundle were only found in the anterior region of the body (the first twenty segments or so) in both bundles; farther back the number of setæ was almost constantly four in the lateral bundles, and the innermost pair were not markedly different in size from the others as they are anteriorly. The absolute size also, particularly as regards thickness, was greater in the case of the setæ borne by the last few segments of the body than in the case of those borne by the first few segments.

The *clitellum* is completely developed all round the body. It is not saddle-shaped. As is generally the case (subject to a few exceptions) in this family of Oligochæta, it has one set of setæ only, those belonging to the xiiith segment. The clitellum also includes a portion of the xith segment.

The first *dorsal pore* lies, as appears to be invariably the case with the species of the genus *Fridericia*, between segments vii./viii. The dorsal pores were sometimes rendered very conspicuous by the extrusion of various bodies from the cœlom by the effects of the corrosive sublimate used in the preserving of the worms. These had frequently remained half inside and half outside the pore. In one case a ripe ovum was partially extruded; this fact is possibly of some interest in relation to oviposition. There is evidently no reason against the possibility of the ova being normally evacuated through the dorsal pores. The probability of this being a normal occurrence is increased by the fact that the ova are not always confined to the xiith segment, which contains the gonad.

The *salivary glands* have a wide main stem, which opens into the œsophagus a little way behind the pharynx. This gives off a few branches dorsally and ventrally, one of which runs forward. The branches themselves do not appear to undergo secondary ramifications. The intestine commences in segment xiv.

The *septal glands* extend back as far as the viith segment, and commence in the ivth. The ante-septal region of the *nephridia* is nearly as large as the post-septal, and has a convoluted duct. The duct leading to the exterior arises near to the septum. The dorsal vessel arises from the intestinal sinus in segment ix.

The *sperm duct funnel* is about three times as long as it is broad. The atrium does not seem to differ from that of other species. It is furnished with a few retractor muscles. The coiled *sperm duct* is supported by a sheet of muscular and connective tissue, which runs from the septum behind the funnel to the atrium itself.

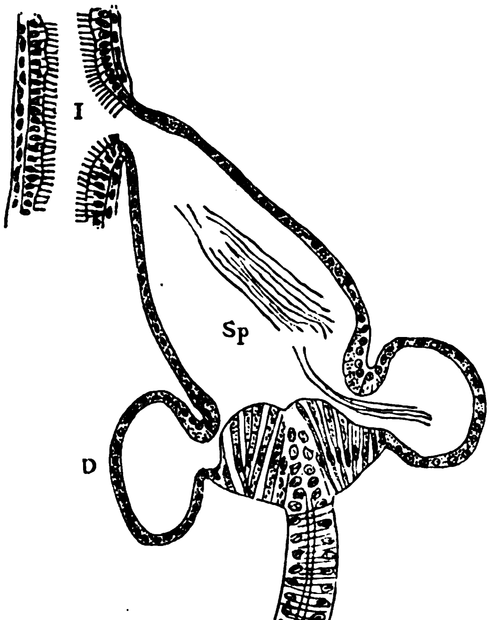

Fig. 2.

A spermatotheca in longitudinal section. I, œsophagus, into which spermatotheca opens; D, diverticula; Sp, bundles of spermatozoa.

The *spermatothecæ* (Fig. 2) are a single pair in segment. The duct is long and narrow; relatively to the minute lumen its walls are thick. It opens into a wide, thin pouch, with numerous radially disposed outgrowths. The junction of the narrow duct with the wide pouch is marked by a hemispherical elevation, consisting of columnar cells increasing in height towards the centre. In transverse section this papilla appears perfectly circular and marked peripherally by a highly refracting band, which looks like a layer of chitin; in the centre it is perforated by the minute duct. The comparatively spacious pouch into which the duct opens communicates with seven radially disposed pouches; possibly it might be considered more accurate to say four, since the appearance of a greater number is produced by a division of some of them, the line of division not coming so far down as the septa between the four primary pouches. These diverticula in no way differ in minute structure from the pouch whence they arise. The pouch itself communicates with the œsophagus.

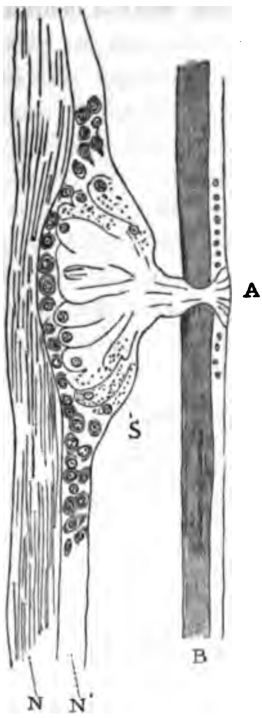

Fig. 3.

A ventral sensory papilla in longitudinal section. A, epidermis of body wall at point where the processes of the cells of the organ reach the exterior; B, body wall; N N′, two layers of nerve cord.

Behind the male pores in each of the three following segments is a single median structure, which seems to be of the nature of a sensory papilla. The first of the three is situated just at the end of the clitellum. Each gland (Fig. 3) consists of a cushion-like mass of cells of a flattened hemispherical contour; it lies immediately beneath the nerve cord, and seems, in fact, to be a dilatation of the nerve cord. The lower part of the sheath of the nerve cord is continuous over the cells which form the organ referred to. The cells of which it is composed are large, pear-shaped, and granular; towards the periphery they are more coarsely granular than centrally. The cells are ten or twelve times as large as those in other regions of the nerve cord. The processes of these cells converge and perforate the longitudinal layer of the body wall; arrived at the epidermis, they spread out into a disc-shaped area, contrasting with the surrounding epidermis. This area appears to be composed of smaller pear-shaped cells, in other respects like those of the deeper lying organ. In front of and behind each of these papilla is a nerve arising from ventral cord, and penetrating the body wall. A cursory glance at these organs would undoubtedly lead to the inference that they were glandular bodies, serving perhaps as organs of adhesion during coitus; the prevalence of such organs among the Oligochæta would support this view of their nature. Their relations, however, to the nerve cord (their enclosure within its sheath, and the absence of any breach between their cells and those of the nerve cord) seem to indicate that they are specialised regions of the nerve cord connected with integumental sense organs. In this case they will in all probability be comparable to the "wing-like processes" which occur in several places upon the nerve cord of *Pachydrilus nervosus,* and one or two other species of *Pachydrilus.* The presence of these structures seems to distinguish the present species of *Fridericia* from any other that has been hitherto described.

VI. *The Land and Fresh-Water Crustacea of the District around Edinburgh.* Part II.—*The Ostracoda and Copepoda.* By Thomas Scott, Esq., F.L.S., Cor. Mem. Glas. Geol. Soc. and Nat. Hist. Soc. of Glasgow.

(Read 19th April 1893.)

In a previous communication I gave a short account of the land and fresh-water Amphipoda and Isopoda of the Edinburgh district; in this paper I propose to notice two of the groups of the Entomostraca, viz., the Ostracoda and Copepoda. I intended to have given an account of these groups during the previous session of the Royal Physical Society, but want of time compelled me, reluctantly, to delay doing so till a more convenient season. One of the chief difficulties in dealing with the larger or "higher" Crustacea is to find the specimens, but the chief difficulty with the micro-forms—

which, as a rule, are plentiful enough—is rather the determination of the species. To critically examine thousands of these minute organisms is a task requiring not only patience, but a considerable amount of time, because it is often absolutely necessary to dissect the specimens in order to determine, not only specific, but, also, generic differences. To simply crush the animal under a cover-glass, and take the risk of finding one or more of the appendages in a favourable position, is, to say the least of it, a clumsy and unsatisfactory method. No doubt, to dissect, for example, a Copepod, perhaps the thirtieth to the fiftieth of an inch in length, limb from limb, in consecutive order, so as to ascertain the exact relative position of each member, and thus be enabled to make a correct comparison of the one with the other, requires some practice and dexterity, yet only in this way can a reliable knowledge of the structure and relationship of the parts be acquired. But, though the difficulty of such a procedure be apparently great, it is quite surmountable—my son, Mr Andrew Scott, to whom I am much indebted for help of this kind in preparing material for the present paper, is often able to prepare a complete series of appendages from a single Copepod, viz., anterior and posterior antennæ, mandibles, maxillæ, anterior and posterior foot-jaws, and the five pairs of thoracic feet, and this has often permitted a satisfactory discrimination to be made, which would otherwise have been well-nigh impossible.

Next session I hope to be able to prepare an account of the Cladocera of the district, when I shall, probably, notice any species belonging to the other groups which may have previously escaped observation.

THE OSTRACODA.

I propose, in the first place, to deal with the Ostracoda of the area.

It will be understood that the district limits are the same as described in my previous paper, and in Mr Evans's memoir on the Mammalia in the *Proceedings of the Royal Physical Society*, published in 1892.

At a meeting of the Royal Physical Society, held on the 22nd of January, 1890, I had the privilege of exhibiting a small collection of Ostracoda, and of drawing attention to a few of the more interesting species that had been obtained within the Edinburgh district; the aim of the present communication is to put on record all the species—common as well as rare—that are known to occur within the prescribed area. But, before proceeding to give an enumeration of the species, it may be desirable to offer a few remarks upon the distribution of the Ostracoda.

Speaking generally, the Ostracoda are to be found almost everywhere where there are pools of water. Some of them are more commonly found in water of questionable purity, such as may be seen stagnant in ditches and marshy ground, and possessing an odour of a rather disagreeable kind; but, while that is the case, I do not remember having ever observed Ostracoda in water that was largely mixed with sewage,—the impurity of the water in which such species are found is usually the result of the decay of vegetable matter in the bottom or round the sides of the pool, or loch. It may be also stated, as a rule, that all the species are more or less confined to still water, as that of ponds, lochs, canals, etc., and are rarely obtained in running water. There are some curious and interesting problems, relating to the laws of distribution of species, presented by the Ostracoda—in one locality a single species may be found in the greatest abundance to the exclusion of almost every other form, while in another locality, where the conditions appear to be equally favourable, that species may be very scarce or entirely absent. To bring out this more clearly, I may relate my experience of a single species, viz., *Cypris incongruens.* In Garvel Park, Greenock, previous to the construction of the James Watt Dock, there were some pools of water, and, during May 1880, the weather being dry and warm, one of these pools dried up. There had been a good deal of conferva in the pool, and this, when the water disappeared, formed a substance, almost like felt, covering the bottom. On removing some of this felt-like material, *Cypris incongruens* was observed in myriads, and, so far as I remember, was the only Ostracod present. During the autumn of 1888 I happened to be several times in the neighbourhood of

Portobello, and visited the brickfield at the west end of the town; in one or two of the pools in the disused part of the brickfield, the same species was in great abundance, to the exclusion of almost every other form. During September 1890, I made an examination of some shallow pools of water on May Island, when *Cypris incongruens* was observed to be moderately common, and this was the only fresh-water Ostracod I found on the island. I have now to notice a still more curious fact relating to the distribution of this species. In September 1887, my son, Mr Andrew Scott, who was, at that time, assistant chemist in the laboratory of the Baker Street Sugar Refinery, Greenock, belonging to Messrs Alexander Scott & Sons,—wrote me as follows:—"I was up at one of the tanks on the roof of the sugar-house, and observed that the bottom was quite yellow. On closer examination the yellow substance turned out to be Ostracoda—chiefly *Cypris incongruens;* there is also a *Candona,* I think" (this was *Candona candida*). "The tank was being cleaned out, so I took some of the mud, etc., for preservation. Now the curious thing is, how did the Ostracods get into the tank, seeing that any water that gathers is rain water, and the tank is cleaned out once a year?"

Being desirous for further information about this matter, I wrote to the manager of the sugar-house, Mr Alexander S. MacLean (whom I have the privilege of counting as one of my friends), drawing his attention to the subject, and asking if he knew of any means by which the Ostracods could have been introduced; and on 21st January 1888, he sent me the following interesting note:—"Now as to the Ostracods, the tanks referred to consist of a set of three, measuring 40 feet by 16 feet by 4 feet 6 inches deep, they are formed of cast-iron plates, and stand about 100 feet above the ground. One is covered with yellow pine boards, the other two are uncovered. They were wont to be supplied with water from Loch Thom, but the supply was shut off at the meter inlet four years ago when the tanks ceased to be used. Rain water collects in the two uncovered tanks, and that is the only water that has entered them since the Loch Thom water was shut off. I know, therefore, of no way by which these little animals could get in except by adhering to the claws of birds. And that this is probably the true means, appears from the fact that, the char-house being idle, birds have all freedom to alight undisturbed in and about the tanks. I have frequently seen starlings, wagtails, and house-sparrows, and sometimes a robin redbreast, sitting on the sides of the tanks." Such is Mr MacLean's account of this interesting example of the apparently erratic distribution of these Ostracods.

In case it may be thought that the Ostracods were descended from those that may have been introduced before the supply of the Loch Thom water was shut off, I should, perhaps, add this further explanation. The only water that could get into the tanks, during the lengthened period they were not in use, was, as stated by my correspondent, supplied from the clouds, and, though that supply is sometimes considerable, it was seldom allowed to collect in any quantity. The uncovered tanks were separated from each other by a partition formed of iron plates; one of the tanks had an outlet pipe flush with the bottom, so that when necessary *all* the water from that tank could be run off; the second tank communicated with the first by a round hole through the iron partition, at about three or four inches from the bottom. In the one tank, therefore, all the water drained off as it fell, while, in the other, not more than a depth of three or four inches could collect, unless the hole in the iron partition was closed, which was rarely done. Being continually exposed to the sun and air, both tanks were consequently dry during a considerable part of the summer, unless the season were unusually wet. Mud, consisting of dust, blown by the wind, and of carbonaceous matter from the chimneys, collected in the bottoms of the tanks, but it was never allowed to accumulate, though the tanks were not in use; as a matter of fact, the tanks had been cleaned out, at least, twice since the time when the Loch Thom water was shut off, and before Ostracods were discovered. When the tanks were cleaned, the rust was carefully chipped or scraped off the cast-iron sides, which were then coated with tar, and the bottoms were swept with a brush; it is, therefore, hardly possible that the Ostracods observed could have been descendants from any that may have been introduced with the Loch Thom water; and, moreover, I do not remember having ever obtained *Cypris incongruens* in Loch Thom.

It has, also, to be kept in mind that Ostracoda die very soon if exposed to the air, though they can survive a few days when enclosed in damp mud or vegetable matter. The eggs of Entomostraca possess much greater vitality than the adult animals, and may, after a considerable lapse of time, be revived, as has been demonstrated by Professor G. O. Sars, who has raised Entomostraca from dried Australian mud; but the case I have described is different, in that the tank was cleaned out with a brush, so that, practically, no mud was left to form a protection, for either adults or eggs, from the scorching rays of the summer's sun, yet nevertheless, here was a species of Ostracod in such immense numbers as to impart a yellow colour to the bottom of the tank.

Cypris incongruens, though thus abundant and occurring in such out-of-the-way places, is yet by no means so ubiquitous as such examples would seem to imply. It is no uncommon experience to seek for it in vain where all the conditions favourable to its existence appear to be present. But this Ostracod is not only seemingly capricious in its selection of a habitat, it is also capable of living under very varied conditions, both as regards the temperature and the purity of the water. Mr David Robertson, the veteran Scottish naturalist, obtained it, many years ago, in a mill cooling-pond at Paisley. "Where the water issued into the pond, the temperature was 90° Fahr., and the surface water 80° Fahr.; the Ostracods were found in the mud farthest from the heat." On the other hand, my son obtained the same species at Greenock, in a ditch where there was very little water, and what there was of it, covered with a coating of ice. It may also be found in brackish, as well as in clean, water, and in water so impure, from decomposing vegetable matter, as to be offensive both to sight and to smell.

It will not be understood, though I have thus tried to illustrate the vagrant distribution of a particular species, that such a distribution is exceptional, or confined to that species. It may be observed, more or less, in many other species belonging to the group. It is this kind of distribution that makes the study of these minute organisms more interesting, because rare forms turn up in such unlikely and exceptional localities, that the expectation is kept always, more or less, active and on the alert.

The Ostracoda, which may thus form a suitable subject for a leisure-time study, are not only of interest to the naturalist, but are also of value from a merely utilitarian point of view, seeing that fish are not indifferent to them as an article of food; hence, it is the experience of the student that limited localities frequented by the trout and the stickleback are not, commonly, the best hunting-grounds for Ostracoda. Another point worth noticing is the dissimilarity of species between the east and the west sides of Scotland. Though a considerable amount of attention has been devoted to the Ostracoda for many years, the difference in this respect remains fairly constant. No doubt, the difference has varied during the course of these years,—species that appeared to be confined to one side have been discovered on the other; but, while there was this tendency to equalisation, the research which led to it also brought to light other forms, and these, being, for the present, at least, apparently confined to the east or the west sides, cause the difference still to remain. The species that are at present apparently confined to the east or the west of Scotland are few in number, and may be best shown in tabulated form, thus:

TABLE I.

Species found on the east side of Scotland, but not hitherto on the west side.	Species found on the west side of Scotland, but not hitherto on the east side.
Cypris pubera, O. F. Müller.	*Scottia browniana*[1] (T. R. Jones).
Erpetocypris violacea, Brady and Norman.	*Erpetocypris robertsoni*, Brady and Norman.
	Cypridopsis newtoni, Brady and Robertson.
	Cypridopsis variegata, Brady and Norman.
	Darwinula stevensoni,[1] Brady and Robertson.

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[1] *Scottia browniana* has been obtained common in a post-Tertiary deposit at Elie in Fifeshire (*see* Proc. Roy. Phys. Soc. Edin., vol. x., p. 334), and *Darwinula stevensoni* from a somewhat similar deposit at the Meadows, Edinburgh (*see* Proc. Roy. Phys. Soc. Edin., vol. x., p. 141).

The following table, by showing what species are found in Scotland, but not in England, and *vice versâ*, may also be of interest.

TABLE II.

Species found in Scotland, but not hitherto known to occur in England.	**Species found in England, but not hitherto known to occur in Scotland.**
Scottia browniana[1] (T. R. Jones).	*Cypria joanna* (Baird).
Erpetocypris robertsoni, Brady and Norman.	*Cypris elliptica*, Baird.
Cyprois flava (Zaddach).	*Cypris cambrica*, Brady and Robertson.
Candona euplectella, Robertson.	*Cypris ornata*, O. F. Müller.
	Cypris clavata, Baird.
	Cypris trigonella, Brady.
	Erpetocypris serrata, Norman.
	Metacypris cordata, Brady and Robertson.
	Limnicythere monstrifica (Norman).

Table III. shows the species found both in England and Scotland, but not in Ireland, and those peculiar to Ireland only.

TABLE III.

Species found in both England and Scotland, but not hitherto in Ireland.	Species hitherto only found in Ireland.
Cyclocypris globosa (G. O. Sars).	*Cypris bispinosa*, Lucas.
Cypris obliqua, Brady.	*Candona elongata*, Brady and Norman.
Erpetocypris strigata (O. F. Müller).	
Erpetocypris tumefacta, Brady and Robertson.	
Erpetocypris olivacea, Brady and Norman.	
Cypridopsis newtoni, Brady and Robertson.	
Candona rostrata, Brady and Norman.	
Candona acuminata (Fischer).	
Ilyocypris gibba (Ramdohr).	
Lymnicythere inopinata (Baird).	

Though only two species are peculiar to the fresh-water Ostracod fauna of Ireland, they are both of special interest.

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[1] *Scottia browniana* is found as a post-Tertiary fossil in several places in the south of England.

The first, *Cypris bispinosa*, is one of the finest of the British species, and the only other two places where it has been observed are the island of Guernsey and Egypt; while the second, *Candona elongata*, has been obtained nowhere else,—its Irish habitat being Lough Neagh.

LOCAL LISTS OF SPECIES.

The following lists of species are intended to exhibit how the Ostracoda vary in number and kinds in different localities in the district, and, also, to show that, while some forms are more or less common to all the localities, others are restricted to one or to only a few places. The lists may also be of use to collectors, by indicating where the rarer species may be obtained, and where the richest gatherings have been made. A few of the species mentioned in this paper are more frequently obtained in brackish than in purely fresh water, but they are included because of their close relationship with true fresh-water species. The true fresh-water and the true marine species merge together in these brackish-water forms, and any boundary line that may be drawn between the two is at best more or less arbitrary.

As Duddingston Loch is in our immediate vicinity, and has, so far, yielded a greater number of species than any other locality within the district, it may be better first to give a list of the Ostracoda that have been obtained in this loch.

Ostracoda obtained in DUDDINGSTON LOCH, near Edinburgh.

Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cypria serena (Koch).
Cypris fuscata (Jurine).
Cypris pubera, O. F. Müller.
Cypris virens (Jurine).
Cypris reticulata, Zaddach.
Erpetocypris reptans (Baird).
Erpetocypris strigata (O. F. Müller).
Erpetocypris tumefacta (Brady and Robertson).
Erpetocypris olivacea, Brady and Norman.
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Cyprois flava (Zaddach).
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona pubescens (Koch).
Candona rostrata, Brady and Norman.
Candona fabæformis (Fischer).
Ilyocypris gibba (Ramdohr).
Limnicythere inopinata (Baird).

Ostracoda obtained in pools at Luffness Links, near Aberlady. These pools have been long known to the botanist if not to the zoologist, and there can be no doubt that they harbour a micro-fauna fully as interesting as their flora. The following species were collected in September 1889:—

Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cypris fuscata (Jurine).
Cypris virens (Jurine).
Erpetocypris reptans (Baird).
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis villosa (Jurine).
Notodromus monacha (O. F. Müller).
Candona candida (O. F. Müller).
Candona pubescens (Koch).
Candona kingsleii, Brady and Robertson.
Candona fabæformis (Fischer).
Ilyocypris gibba (Ramdohr).

Threipmuir Reservoir, two to three miles south of Balerno, is formed in one of the valleys of the Pentlands; the surrounding scenery has a rather bleak and barren appearance, especially towards the Pentlands. The reservoir is of considerable extent, and to make a careful examination of it would require the use of a boat, so that a tow-net and dredge could be used. If that were done it is quite possible that some interesting Entomostraca might be captured. I have only been able to make an examination of the sides of the reservoir with a hand-net, and the following were the Ostracoda obtained:—

Cypria ophthalmica (Jurine).
Cypria serena (Koch).
Cpyris fuscata (Jurine).
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis vidua (O. F. Müller).
Candona candida (O. F. Müller).
Candona kingsleii, Brady and Robertson.
Candona acuminata (Fischer).
Candona sp.

It sometimes happens that the ditches by which the surface water drains off into a loch or pond harbours a richer micro-fauna than the loch or pond to which they are tributaries. This was my experience at Harelaw Dam, which was visited about the same time as Threipmuir. The dam itself yielded very little in the way of Ostracoda, but in a ditch that for a considerable distance runs parallel with the dam, I found the following species of Ostracoda, and one or two rare things belonging to another group:—

Cypria ophthalmica (Jurine).
Cypria serena (Koch).
Erpetocypris reptans (Baird).
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Candona candida (O. F. Müller).
Candona kingsleii, Brady and Robertson.
Candona acuminata (Fischer).
Ilyocypris gibba (Ramdohr).

In company with an old friend—Mr Thomas Struthers—who is thoroughly familiar with the district around Edinburgh, I examined some pools near GOREBRIDGE in December 1889, and obtained the following species:—

Cypria ophthalmica (Jurine).
Erpetocypris tumefacta (Brady and Robertson).
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona pubescens (Koch).
Candona kingsleii, Brady and Robertson.

At SEAFIELD, near Dunbar, there is an old disused brickfield in which are several pools of water. The brickfield is close to the sea-shore, so that during high tides the sea flows into the pools and causes the water to become brackish. The little shrimp-like Crustaceans, *Mysis vulgaris* and *Palæmonetes varians*, frequent some of the pools. Being desirous to learn about the Ostracod fauna of these pools, I got my friend Mr Jamieson, Assistant Naturalist to the Fishery Board, to collect some material and send it to me. I also, in company with him, made a personal examination of the pools. The following species of Ostracoda were obtained:—

Cypris prasina, Fischer.
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis aculeata, Lilljeborg.
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona pubescens (Koch).
Ilyocypris gibba (Ramdohr).
Cytheridea torosa (Jones).

The brackish-water pools at the mouth of the COCKLEMILL BURN, near Largo, Fifeshire, were examined, and yielded the following species:—

Cypria ophthalmica (Jurine).
Cypris (?) *virens* (Jurine).
Potamocypris fulva, Brady.
Candona lactea, Baird.
Cytheridea torosa (Jones).

Along with the species enumerated from these two brackish-water localities, there were several others more nearly allied to the marine than the fresh-water forms, which, though not entered in the regular lists, may be mentioned to show how the so-called marine and fresh-water species sometimes mingle together. The following are the species referred to:—*Cythere lutea*, Müller, *Cythere pellucida*, Baird, *Cythere villosa* (G. O. Sars), *Cythere albomacuta*, Baird, and *Cytherura gibba*, Müller. These were not dead shell, but were living in the pools along with the others. There were also some Foraminifera, as *Miliolina fusca*, *Lituola canariensis*, etc., associated with these Ostracoda.

Raith Lake, near Kirkcaldy, is an artificial lake, formed during last century. It is situated within the pleasure-grounds of the Raith estate, the property of Mr Munro-Ferguson, M.P., and is private. Permission to visit the loch may be obtained by applying to Mr Prentiss, the factor on the estate. This little lake harbours an abundant Crustacean fauna, especially Ostracoda and Cladocera. The loch is said to be 25 feet deep in some places, and to cover not less than 21 acres. The following are the species of Ostracoda obtained in Raith Lake in August 1890:—

Cypria ophthalmica (Jurine).
Cypria serena (Koch).
Erpetocypris reptans (Baird).
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Notodromas monacha (O. F. Müller).
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona rostrata, Brady and Norman.
Candona fabæformis (Fischer).
Ilyocypris gibba (Ramdohr).
Limnicythere inopinata (Baird).

Lindores Loch, near Newburgh, Fifeshire. Whether this little loch, which is situated in a district profoundly interesting to the student of old-world history, be to the zoologist or botanist a "happy hunting-ground" or not, it is certainly well known to, and much frequented, during the proper season, by the fraternity of the "roaring game." Often on the ice-bound surface of this loch the fate—not of kingdoms certainly but what is nearly of equal importance to those engaged in the contest—of the "clubs" of Fifeshire and of Perthshire, and sometimes of other shires as well, is decided for the year. It is easy for the onlooker to see by the gestures and ejaculations of the combatants that momentous issues are at stake. It is no wonder, then, that the humble seeker after Ostracods and Copepods should desire to find out if there was anything of special interest to him in or about this famous loch. The following species rewarded my examination of it in July 1886. I have not been there since.

Cypria exculpta (S. Fischer).
Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Erpetocypris reptans (Baird).
Cypridopsis vidua (O. F. Müller).
Candona lactea, Baird.
Candona rostrata, Brady and Robertson.
Limnicythere inopinata (Baird).

The next list is that of the Ostracoda obtained in LOCH LEVEN, Kinross-shire, in June 1890. (For a description of this loch see the *Ninth Annual Report of the Fishery Board for Scotland*, 1891.)

Cypria exculpta (Fischer).
Cypria ophthalmica (Jurine).
Cypria serena (Koch).
Erpetocypris reptans (Baird).
Erpetocypris strigata (O. F. Müller).
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona kingsleii, Brady and Robertson.
Candona pubescens (Koch).
Ilyocypris gibba (Ramdohr).
Cytheridea lacustris (G. O. Sars).
Limnicythere sancti-patrici, Brady and Robertson.
Limnicythere inopinata (Baird).

On the 18th of September 1890, I visited LOCHGELLY LOCH, Fifeshire, but, from want of time, was able to examine only a small part of it. The gathering then made was, however, rich in micro-crustacea, and showed that a thorough examination would, doubtless, have yielded satisfactory results. Nineteen species of Ostracoda were obtained at this time, as follows:—

Cypria exculpta (S. Fischer).
Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cypris pubera, O. F. Müller.
Cypris obliqua, Brady.
Erpetocypris reptans (Baird).
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Notodromas monacha (O. F. Müller).
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona pubescens (Koch).
Candona kingsleii, Brady and Robertson.
Candona fabæformis (Fischer).
Candona hyalina, Brady and Robertson.
Candona ambigua, Scott.
Ilyocypris gibba (Ramdohr).
Limnicythere inopinata (Baird).

KILCONQUHAR LOCH, in the vicinity of Elie, Fifeshire, is a fine sheet of water. The sides are overgrown with vegetation, and appear to be a good hunting-ground for Entomostraca;

but no visitors are allowed near it, except on the north side, near the village of Kilconquhar. I visited the loch during September 1890, and obtained a fairly satisfactory gathering. The following Ostracoda were got:—

Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cypris pubera, O. F. Müller.
Cypris virens (Jurine).
Erpetocypris reptans (Baird).
Erpetocypris tumefacta (Brady and Robertson).
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona kingsleii, Brady and Robertson.
Candona fabæformis (Fischer).
Ilyocypris gibba (Ramdohr).
Limnicythere inopinata (Baird).

KINGHORN LOCH, which is reached from Burntisland by the road that passes the "Oil Works," is close by the roadside and readily accessible. On the west side the ground is marshy, and harbours a few interesting species. Large and fine specimens of *Cypris pubera* were obtained at the time when I, along with my good friend Mr Bennie, visited the loch in September 1889. The following were the species gathered at that time:—

Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cypris pubera, O. F. Müller.
Erpetocypris reptans (Baird).
Erpetocypris olivacea, Brady and Norman.
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona lactea, Baird.
Candona pubescens (Koch).
Ilyocypris gibba (Ramdohr).

The BLACK LOCH, near Loch Glow, among the Cleish Hills, in the west of Fifeshire, was visited on the 14th September 1889, and yielded a few rare species. There are four little lochs here, in hollows among the hills, and they all appear to form suitable haunts for Entomostraca and other microscopic life. The following species were obtained in the Black Loch:—

Cypria ophthalmica (Jurine).
Cypria lævis (O. F. Müller).
Cyclocypris globosa (G. O. Sars).
Erpetocypris strigata (O. F. Müller).
Erpetocypris tumefacta, Brady and Robertson.
Erpetocypris olivacea, Brady and Norman.
Erpetocypris sp.
Cypridopsis vidua (O. F. Müller).
Cypridopsis villosa (Jurine).
Potamocypris fulva, Brady.
Candona candida (O. F. Müller).
Candona rostrata, Brady and Norman.
Candona kingsleii, Brady and Robertson.
Ilyocypris gibba (Ramdohr).
Limnicythere inopinata (Baird).

CLASSIFIED LIST OF OSTRACODA OBTAINED IN THE DISTRICT AROUND EDINBURGH.

The following classified list includes all the genera and species known to occur in the district, and they are all represented in my collection. In order to make the list useful to those who may not possess the more recent literature on the Ostracoda, I have added a few synonyms; and for further information would refer the reader to the "Monograph of the Marine and Fresh-Water Ostracoda of the North Atlantic and of North-Western Europe," Section I., "Podocopa," by Professor G. S. Brady and the Rev. Canon Norman.

Family CYPRIDIDÆ.

This family includes all but a few of the fresh-water species.

Genus Cypria, Zenker (1854).

Cypria exculpta (S. Fischer, 1854).

1868. *Cypris striolata*, Brady, Mon. Brit. Ostrac., p. 372, pl. xxiv., figs. 6-10.
1880. *Cypris granulata*, Robertson, Fresh and Brackish Water Ostrac. of Clydesdale, p. 18 (young).
1889. *Cypria exculpta*, Brady and Norman, Mon. Ostrac. N. Atlantic and N.-W. Europe, p. 68, pl. xi., figs. 1-4.

Habitat.—Loch Leven, Kinross-shire; Lindores Loch, Lochgelly Loch, Lurg Loch, and Loch Dow, Fifeshire. Frequent.

Cypria ophthalmica (Jurine, 1820).

1835. *Cypris compressa*, Baird, Trans. Berw. Nat. Club, vol. i., p. 100, pl. iii., fig. 16.
1868. *Cypris compressa*, Brady, *op. cit.*, p. 372, pl. xxiv., figs. 1-5; pl. xxxvi., fig. 6.
1875. *Cypris compressa*, Brady, Crosskey, and Robertson, Post-Tert. Entom., p. 127, pl. i., figs. 5, 6.
1889. *Cypria ophthalmica*, Brady and Norman, *op. cit.*, p. 691, pl. xi., figs. 5-9.

Habitat.—Common throughout the district.

Cypria lævis (O. F. Müller, 1785).

1820. *Monoculus ovum*, Jurine, Hist. de Monocles, p. 179, pl. xix., figs. 18, 19.
1835. *Cypris minuta*, Baird, Brit. Entom., p. 155, pl. xviii., figs. 7, 8.
1868. *Cypris ovum*, Brady, *op. cit.*, p. 373, pl. xxiv., figs. 33, 34, 43-45; pl. xxxiv., fig. 8.
1875. *Cypris ovum*, Brady, Crosskey, and Robertson, *op. cit.*, p. 123, pl. i., figs. 5, 6.
1889. *Cypria lævis*, Brady and Norman, *op. cit.*, p. 69.

Habitat.—Frequent throughout the district.

Cypria serena (Koch, 1838).

1868. *Cypris lævis*, Brady, *op. cit.*, p. 374, pl. xxiv., figs. 6-8.
1875. *Cypris lævis*, Brady, Crosskey, and Robertson, *op. cit.*, p. 126, pl. i., figs. 25-28.
1889. *Cypria serena*, Brady and Norman, *op. cit.*, p. 70.

Habitat.—Generally distributed throughout the district.

Genus Cyclocypris, Brady and Norman (1889).

Cyclocypris globosa (G. O. Sars, 1863).

1868. *Cypris cinerea*, Brady, *op. cit.*, p. 374, pl. xxiv., figs. 39-42; pl. xxxvi., fig. 7.
1875. *Cypris cinerea*, Brady, Crosskey, and Robertson, *op. cit.*, p. 126, pl. ii., figs. 6, 7.
1889. *Cyclocypris globosa*, Brady and Norman, *op. cit.*, p. 71, pl. xiv., figs. 1, 2; pl. xi., figs. 10-18.

Habitat.—Loch Leven; Loch Fitty, Fifeshire; Black Loch and Loch Dow.

Genus Cypris, Müller (1785).

Cypris fuscata, Jurine (1820).

1868. *Cypris fusca*, Brady, *op. cit.*, p. 362, pl. xxiii., figs. 10-15.
1889. *Cypris fuscata*, Brady and Norman, *op. cit.*, p. 73, pl. xii., figs. 3, 4.

Habitat.—Duddingston Loch, ponds at the Braid Hills, Edinburgh; ponds near Dunbar; and Loch Fitty, Fifeshire.

Cypris incongruens, Ramdohr (1808).

1868. *Cypris incongruens*, Brady, *op. cit.*, p. 362, pl. xxiii., figs. 16-22.
1889. *Cypris incongruens*, Brady and Norman, *op. cit.*, p. 73, pl. xii., figs. 8, 9.

Habitat.—Brickfields at Portobello; side of the Union Canal at Slateford; May Island.

Cypris pubera, O. F. Müller (1785).

1868. *Cypris punctillata*, Brady, *op. cit.*, p. 365, pl. xxvi., figs. 1-7; pl. xxxvi., fig. 11.
1889. *Cypris pubera*, Brady and Norman, *op. cit.*, p. 74.

Habitat.—Duddingston Loch, Edinburgh; Kilconquhar Loch, Kinghorn Loch, Lochgelly Loch, Fifeshire.

Cypris virens (Jurine, 1820).

1868. *Cypris virens*, Brady, *op. cit.*, p. 364, pl. xxiii., figs. 23-32; pl. xxxvi., fig. 1.
1889. *Cypris virens*, Brady and Norman, *op. cit.*, p. 74.

Habitat.—Frequent throughout the district—Duddingston Loch, pools at Luffness Links (large and fine specimens), pools at Slateford, Kilconquhar Loch.

Cypris reticulata, Zaddach (1844).

1868. *Cypris tessellata*, Brady (in part), *op. cit.*, p. 336, pl. xxiii., figs. 39-45.
1880. *Cypris tessellata*, Robertson, Fresh and Brackish Water Ostrac. of Clydesdale, p. 15.
1889. *Cypris reticulata*, Brady and Norman, *op. cit.*, p. 76, pl. viii., figs. 1, 2; pl. xi., figs. 5-7.

Habitat.—Camilla Loch, Fifeshire (August 20, 1890); Duddingston Loch (April 8, 1893).

Cypris obliqua, Brady (1868).

1889. *Cypris obliqua*, Brady and Norman, *op. cit.*, p. 77, pl. xii., fig. 10.

Habitat.—Lurg Loch (near Loch Glow), Kinross-shire; Lochgelly Loch, Fifeshire. The colour of the shell of this species from these two localities was a fine, light, chocolate-brown; the colour of the shells of the same species from a tarn near Cragengower Farm, Cumbrae, was bright green (Robertson).

Cypris prasina, Fischer (1855).

1850. *Cypris strigata*, Baird, Brit. Entom., p. 157 (not *C. strigata*, Müller).
1868. *Cypris salina*, Brady, *op. cit.*, p. 368, pl. xxvi., figs. 8-13.
1889. *Cypris prasina*, Brady and Norman, *op. cit.*, p. 78.

Habitat.—Pools in an old brickfield at Seafield, near Dunbar, August 1890.

Genus **Erpetocypris**, Brady and Norman (1889).

Erpetocypris reptans (Baird, 1835).

1850. *Candona similis*, Baird, Brit. Entom., p. 162, pl. xix., figs. 2-2*a* (young).
1868. *Cypris reptans*, Brady, *op. cit.*, p. 370, pl. xxv., figs. 10-14; pl. xxxvi., fig. 4.
1889. *Erpetocypris reptans*, Brady and Norman, *op. cit.*, p. 84, pl. xiii., fig. 27.

Habitat.—More or less common throughout the district.

Erpetocypris strigata (O. F. Müller, 1785).

1889. *Erpetocypris strigata*, Brady and Norman, *op. cit.*, p. 85, pl. viii., figs. 14, 15.

Habitat.—Duddingston Loch, common; Loch Leven, rare; Black Loch (near Loch Glow), 14th September 1889.

Erpetocypris tumefacta (Brady and Robertson).

1870. *Cypris tumefacta*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 13, pl. iv., figs. 4-6.
1889. *Erpetocypris tumefacta*, Brady and Norman, *op. cit.*, p. 87, pl. viii., figs. 5-7; pl. xiii., fig. 18.

Habitat.—Duddingston Loch, and several other places within the district.

Erpetocypris olivacea, Brady and Norman.

1889. *Erpetocypris olivacea*, Brady and Norman, *op. cit.*, p. 89, pl. i., figs. 3, 4.

Habitat.—Duddingston Loch, not very common; Kinghorn Loch, rare; Black Loch (near Loch Glo

Genus **Cypridopsis**, Brady.

Cypridopsis vidua (O. F. Müller, 1785).

1868. *Cypridopsis vidua*, Brady, *op. cit.*, p. 375, pl. xxiv., 27-36, 46.
1889. *Cypridopsis vidua*, Brady and Norman, *op. cit.*, p. 89.

Habitat.—Generally distributed throughout the district.

Cypridopsis aculeata (Lilljeborg, 1853).

1868. *Cypridopsis aculeata*, Brady, *op. cit.*, p. 376, pl. xxiv., figs. 16-20; pl. xxxvi., fig. 10.
1889. *Cypridopsis aculeata*, Brady and Norman, *op. cit.*, p. 90.

Habitat.—Pools in an old brickfield at Seafield, near Dunbar.

Cypridopsis villosa (Jurine, 1820).

1868. *Cypridopsis villosa*, Brady, *op. cit.*, p. 377, pl. xxiv., figs. 11-15; pl. xxxvi., fig. 9.

Habitat.—Generally distributed throughout the district, but not so common as *Cypridopsis vidua.*

Genus **Potamocypris**, Brady (1870).

Potamocypris fulva, Brady.

1889. *Potamocypris fulva*, Brady and Norman, *op. cit.*, p. 93, pl. xxii., figs. 13-17.

Habitat.—Generally distributed throughout the district; and moderately common in some localities, as in marshy ground at Gorebridge, and at Raith Lake, Kirkcaldy.

Genus **Notodromas**, Lilljeborg (1853).

Notodromas monacha (O. F. Müller), 1785.

1889. *Notodromas monacha*, Brady and Norman, *op. cit.*, p. 96.

Habitat.—Luffness Links, near Aberlady; Lochgelly Loch and Camilla Loch, Fifeshire. Frequent in all the three localities.

Genus **Cyprois**, Zenker (1854).

Cyprois flava (Zaddach).

1838. (?) *Cypris gibbosa*, Baird, Mag. Zool. and Bot., vol. ii., p. 137, pl. v., fig. 15.
1844. *Cypris flava*, Zaddach, Syn. Crust. Prus. Prodr., p. 33.
1850. *Cypris gibbosa*, Baird, Brit. Entom., p. 156, pl. xix., fig. 8.
1854. *Cyprois dispar*, Zenker, Mon. der Ostrac. (Archiv für Naturgesch.), p. 18.
1889. *Cyprois flava*, Brady and Norman, *op. cit.*, p. 97, pl. viii., figs. 18, 19; pl. xii., figs. 13-21, 38.

Habitat.—Duddingston Loch, upper end, common (1889). Mr David Robertson has obtained this species in Burnside Loch, near Rutherglen. It is thought that the *Cypris gibbosa* of Dr Baird is, probably, this species, and, if so, his name ought to have precedence of the other. Dr Baird's figure of *Cypris gibbosa* is, certainly, very different from the specimens of *Cyprois flava* obtained in Duddingston Loch. He also describes the shell as "much elevated on the upper margin, the centre exhibiting a large gibbosity or hump," and also as being "of a light green colour"—characters which do not very closely agree with the Duddingston specimens.

Genus **Candona**, Baird (1845).

Candona candida (O. F. Müller, 1785).

1889. *Candona candida*, Brady and Norman, *op. cit.*, p. 98, pl. x., figs. 1, 2, 14-23.

Habitat.—Generally distributed, and common throughout the district.

Candona lactea, Baird.

1868. *Candona lactea*, Brady, Mon. rec. Brit. Ostrac., p. 382, pl. xxiv., figs. 55-58.
1868. *Candona detecta*, idem, ibidem (var.), p. 384, pl. xxiv., figs. 35-38; pl. xxxvii., fig. 2.
1889. *Candona lactea*, Brady and Norman, *op. cit.*, p. 100.

Habitat.—Generally distributed, but not so common as the last. The young of *Candona candida*, which is a very variable species, are sometimes apt to be mistaken for

Candona lactea; careful discrimination is, therefore, necessary. *Candona lactea* is somewhat cylindrical in shape, moderately robust, and with the ends evenly rounded.

Candona pubescens (Koch).

1837. *Cypris pubescens*, Koch, Deutschlands Crustaceen, H. 11, p. 5.
1838. (?) *Cypris compressa*, idem, ibidem, H. 21, p. 17.
1868. *Candona compressa*, Brady, Mon. rec. Brit. Ostrac., p. 382, pl. xxvi., figs. 22-27.
1868. *Candona albicans* idem, ibidem, p. 381, pl. xxv., figs. 20-25; pl. xxxvi., fig. 12.
1889. *Candona pubescens*, Brady and Norman, *op. cit.*, p. 101, pl. xii., figs. 32-37.

Habitat.—Duddingston Loch, Loch Leven, Luffness Links, Kinghorn Loch, brackish-water pools in an old brickfield near Dunbar.

Candona rostrata, Brady and Norman.

1889. *Candona rostrata*, Brady and Norman, *op. cit.*, p. 101, pl. ix., figs. 11, 12, 12*a* and *b*; pl. xii., figs. 22-31.

Habitat.—Duddingston Loch, Raith Lake, Lurg Loch, Lindores Loch. Not very common.

Candona kingsleii, Brady and Robertson.

1870. *Candona kingsleii*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 17, pl. ix., figs. 9-12.
1889. *Candona kingsleii*, Brady and Norman, p. 102, pl. ix., figs. 19-22; pl. xiii., fig. 19.

Habitat.—Generally distributed. Frequent in Duddingston Loch.

Candona fabæformis (Fischer, 1851).

1870. *Candona diaphana*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 18, pl. v., figs. 1-3.
1889. *Candona fabæformis*, Brady and Norman, *op. cit.*, p. 103, pl. ix., figs. 1-4.

Habitat.—Duddingston Loch, frequent; pond on north side of Corstorphine Hill, common; Luffness Links; Loch Fitty; etc.

Candona acuminata (Fischer, 1851).

1889. *Candona acuminata*, Brady and Norman, *op. cit.*, p. 104, pl. ix., figs. 9, 10; pl. x., figs. 5, 6.

Habitat. — Ditch beside Harelaw Dam; Threipmuir Reservoir, Balerno; Loch Fitty, Fifeshire. Not common.

Candona euplectella, Robertson.

1880. *Candona euplectella*, Robertson, Fresh and Brackish Water Ostracoda of Clydesdale, etc., p. 23.

1889. *Candona euplectella*, Brady and Norman, *op. cit.*, p. 105, pl. ix., figs. 7, 8, 8*a*.

Habitat.— Loch Dow, near Loch Glow, Kinross-shire, 14th September 1889. Rather rare.

Candona hyalina, Brady and Robertson.

1870. *Candona hyalina*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 18, pl. ix., figs. 5-8; pl. v., figs. 4-11.

1889. *Candona hyalina*, Brady and Norman, *op. cit.*, p. 247 (woodcuts of ♂).

Habitat.—Threipmuir Reservoir, near Balerno (♂); Loch Fitty, Fifeshire; Loch Dow, near Loch Glow, Kinross-shire (♀).

Candona ambigua, Scott.

1891. *Candona ambigua*, Scott, Invert. Fauna of Inland Waters of Scot. (Ninth Annual Report of the Fishery Board for Scotland), p. 277, pl. iv., figs. 7*a-c*.

Habitat.—Lochgelly Loch and Loch Fitty, Fifeshire. Not common.

Genus **Ilyocypris**, Brady and Norman (1889).

Ilyocypris gibba (Ramdohr, 1808).

1868. *Cypris gibba*, Brady, *op. cit.*, p. 369, pl. xxiv., figs. 47-54; pl. xxxvi., fig. 2.

1889. *Ilyocypris gibba*, Brady and Norman, *op. cit.*, p. 107, pl. xxii., figs. 1-5.

Habitat.—Duddingston Loch, 1888; vicinity of Gorebridge, 1889; Kinghorn Loch, 1889; Kilconquhar Loch, 1890; Loch Leven, 1890; Lochgelly Loch, 1890.

Family CYTHERIDÆ.

Genus **Limnicythere**, Brady (1867).

Limnicythere inopinata (Baird, 1850).

1868. *Limnicythere inopinata*, Brady, *op. cit.*, p. 419, pl. xxix., figs. 15-18.
1889. *Limnicythere inopinata*, Brady and Norman, *op. cit.*, p. 170, pl. xvii., figs. 18, 19 (var. *compressa*).

Habitat.—Duddingston Loch, 1889; Loch Leven, 1890; Lindores Loch, 1886; Kilconquhar Loch, 1890; Raith Lake, 1890; Lochgelly Loch, 1890; etc.

Limnicythere sancti-patrici, Brady and Robertson, 1869.

1889. *Limnicythere sancti-patrici*, Brady and Norman, *op. cit.*, p. 171, pl. xvii., figs. 1, 2.

Habitat.—Loch Leven, Kinross-shire, 1890. (Obtained in a post-Tertiary deposit at Holyrood—see *Proc. Roy. Phys. Soc.*, vol. x., p. 143, 1889.)

Genus **Cytheridea**, Bosquet, 1850.

Cytheridea lacustris (G. O. Sars, 1862).

1889. *Cytheridea lacustris*, Brady and Norman, *op. cit.*, p. 176.

Habitat. — Loch Leven, frequent, 1890; canal near Morningside, Edinburgh (David Robertson).

Cytheridea torosa (Jones, 1850).

1868. *Cytheridea torosa*, Brady, *op. cit.*, p. 425, pl. xxviii., figs. 7-12; pl. xxxix., fig. 5.
1889. *Cytheridea torosa*, Brady and Norman, *op. cit.*, p. 175.

Habitat.—Brackish-water pools at the mouth of the Cocklemill Burn, near Largo, July 1890; brackish-water pools in an old brickfield at Seafield, near Dunbar, August 1890.

The preceding list of Ostracoda contains thirty-six species belonging to twelve genera; and it is not improbable that, owing to the erratic distribution of the group, the list may be still further increased when the district has been more thoroughly examined.

THE COPEPODA.

I shall now proceed to give a short account of the Copepoda of the district.

This group is equally interesting with the preceding one, but rather more difficult to deal with; they want the hard shell-like covering of the Ostracoda, which allows of those organisms being conveniently mounted and preserved as cabinet specimens. The only manner in which the Copepoda can be preserved is by mounting them in balsam, or some other suitable medium, or by keeping them in methylated spirits; yet, notwithstanding this difficulty, they form a very profitable leisure-time study.

The distribution of the Copepoda is, perhaps, not so capricious as that of the Ostracoda, yet here, as in the other group, we meet with examples of special interest. I shall mention one or two of these. In 1892 I had an opportunity of making an examination of Loch Morar,[1] in Inverness-shire, and obtained a number of rare Entomostraca; but, though the Copepoda were numerously represented, not a single specimen of *Canthocamptus minutus* was observed, and this is one of the most common of the fresh-water *Harpacticidæ*. I do not, of course, mean to say that this species was entirely absent, but only, that, though a careful examination of the material collected was made (partly to ascertain if this *Canthocamptus* was present), no specimens were obtained. In the *Journal of Microscopical Science* for 1868, Professor G. S. Brady described a small species of Copepod, specimens of which had been sent to him by Mr Atthey. They had been found by Mr Atthey "living amongst films of gelatinous algæ" on "the damp roof of the pit-workings of the low main, West Cramlington Colliery, near Newcastle," and the species was named *Attheyella cryptorum*, after its discoverer. The locality described appeared to be the only known habitat of the species till last year, when it was obtained in Loch Morar, in material collected by dragging a small tow-net through the plants and algæ in the shallow water at the head of the loch. It has been obtained, more recently, in material, collected by hand-net, from a ditch in the neighbourhood of Harelaw Dam, Balerno, near Edinburgh, and also in Duddingston Loch.

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[1] An account of this loch will be found in the Annual Report of the Fishery Board for Scotland for 1893.

Equally interesting is the distribution of *Diaptomus serricornis*, Lilljeborg. This species was not known to be a member of the British fauna till it was discovered in tow-net gatherings from Loch Mullach, Corrie, Sutherlandshire, collected by Mr W. S. Caine.[1] After its discovery in this loch, it was ascertained that Mr David Robertson had taken the same species in a pond, near Lerwick, in 1867, but it had remained since that time unnoticed in print. At present the only known British habitats for *Diaptomus serricornis* are the two places here mentioned. It occurs "in fresh-water lakes at Lumbowski in Russian Lapland," and this, so far, is the only European district where it has been obtained, unless *Diaptomus wierzejskii*, Richard, be held as being merely a local variety of *Diaptomus serricornis* (and really the difference between these two forms seems to be so very small that they can hardly be considered as specifically distinct). *Diaptomus wierzejskii* has been recorded from Spain (neighbourhoods of Madrid and Valladolid) and from Saxony. If, therefore, we are to consider these two forms as belonging to the one species, its known distribution is thus of considerable extent, and may indicate that, though it is only recorded from a few localities, it will yet be found of more frequent occurrence than is apparent at present.

The following lists of Copepoda from a few of the principal places within the district, will help to show how this group is locally distributed, and how different species are associated together. These local lists are not to be considered exhaustive, but simply as an effort to bring together the species that have been obtained in the various localities, and thus far satisfactorily determined. The first list will be that of the species obtained in the loch at Duddingston—a loch that has from time immemorial been the resort of both the zoologist and botanist. The names of not a few who have been eminent in one or other of these departments could be given who have been interested in the fauna and flora of Duddingston Loch.

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[1] See Scottish Naturalist for October 1891, p. 172; also A Revision of the British Species of Fresh-Water Cyclopidæ and Calanidæ, by Professor Brady, p. 36 (1891).

Copepoda obtained in DUDDINGSTON LOCH:

Diaptomus gracilis, G. O. Sars.
Cyclops signatus, Koch.
Cyclops bicuspidatus, Claus.
Cyclops thomasi, Forbes.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Cyclops phaleratus, Koch.
Cyclops fimbriatus, Fischer.
Canthocamptus minutus (Müller).
Canthocamptus northumbricus, Brady.
Attheyella spinosa, Brady.
Attheyella cryptorum, Brady.

LOCH LEVEN, KINROSS-SHIRE.—In 1890 I found *Cyclops* very abundant in this loch, but only a few species were obtained, as shown by the following list. The other fresh-water groups were also very sparingly represented.

Diaptomus gracilis, G. O. Sars.
Cyclops signatus, Koch.
Cyclops strenuus, Fischer.
Cyclops vicinus,[1] Uljanin.
Cyclops serrulatus, Fischer.
Cyclops fimbriatus, Fischer.
Canthocamptus minutus (Müller).
Attheyella spinosa, Brady.

RAITH LAKE, KIRKCALDY.—This loch, though comparatively of small size, yielded several interesting species. It is well worth a visit, not only on account of its abundant micro-fauna, but also because of its beautiful and picturesque surroundings.

The Copepoda obtained in this little loch were as follows:—

Diaptomus gracilis, G. O. Sars.
Cyclops signatus, Koch.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Cyclops affinis, G. O. Sars.
Cyclops phaleratus, Koch.
Cyclops fimbriatus, Fischer.
Canthocamptus minutus, Müller.

LOCHGELLY LOCH.—The following species of Copepoda were obtained in Lochgelly Loch:—

Diaptomus gracilis, G. O. Sars.
Cyclops signatus, Koch.
Cyclops phaleratus, Koch.
Cyclops serrulatus, Fischer.
Cyclops thomasi, Forbes.
Cyclops viridis (Jurine).
Cyclops fimbriatus, Fischer.
Canthocamptus minutus (Müller).
Attheyella spinosa, Brady.

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[1] See Prof. Brady's Revision of the British Cyclopidæ and Calanidæ, p. 12 (1891).

CLASSIFIED LIST OF THE COPEPODA OBTAINED IN THE DISTRICT AROUND EDINBURGH.

Family CALANIDÆ.

Genus **Diaptomus**, Westwood (1836).

Diaptomus castor (Jurine).

1785. *Cyclops cæruleus*, Müller, Entomostraca, p. 102, pl. xv., figs. 1-9.
1820. *Monoculus castor*, Jurine, Hist. des Monoc., p. 50, pls. iv.-vi.
1850. *Diaptomus castor*, Baird, Brit. Entom., p. 219, pl. xxvi.
1891. *Diaptomus castor*, Brady, Revision of the Brit. Sp. of F.-W. Cyclop. and Calanidæ, p. 27, pl. xi., figs. 1-6.

Habitat.—Braid Ponds, near Edinburgh, August 1888.[1]

Diaptomus gracilis, G. O. Sars.

1863. *Diaptomus gracilis*, G. O. Sars, Videnskabsselsk. Forhandl., 1862, p. 9.
1863. *Diaptomus westwoodii*, Lubbock, Trans. Linn. Soc., vol. xxiv., p. 203, pl. xxxi., figs. 1-6.
1888. *Diaptomus graciloides*, Lilljeborg, Bull. Soc. Zool. de France, xiii., p. 156.
1889. *Diaptomus graciloides*, De Guerne and Richard, Revision des Calanides d'eau douce, p. 36, pl. i., figs. 26, 27.
1889. *Diaptomus gracilis*, idem, ibidem, p. 14, pl. ii., figs. 12, 16, 20.
1891. *Diaptomus gracilis*, Brady, *op. cit.*, p. 29, pl. xi., figs. 7-9; pl. xii., figs. 1-8.

Habitat.—Generally distributed throughout the district.

Genus **Eurytemora**, Giesbrecht (1881).

Eurytemora clausii (Hoek).

1876. *Temora clausii*, Hoeck, Tijdsch. d. Nederl. Dierkund., Vereenig iii., p. 23, pls. iv. and v.
1878. *Temora velox*, Brady, Mon. Brit. Copep., vol. i., p. 56, pl. vi., figs. 1-5.
1889. *Eurytemora lacinulata*, De Guerne and Richard, *op. cit.*, p. 82, figs. 44, 45.
1891. *Eurytemora clausii*, Brady, Revision of the Brit. Sp. of F.-W. Cyclop. and Calan., p. 40, pl. xiii., figs. 1-5.

Habitat.—Brackish-water pools in an old brickfield at Seafield, near Dunbar, August 1890; in brackish-water pools at Seafield, near Leith, 1892; brackish-water pools by the shore at Aberlady, 5th September 1889.

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[1] Ann. Scot. Nat. Hist., p. 202 (1892).

Eurytemora affinis (S. A. Poppe).

1881. *Temora affinis*, Poppe, Abhandl. des Naturw. ver Bremen, vi., p. 55, pl. iii., figs. 1-14.
1889. *Eurytemora affinis*, De Guerne and Richard, *op. cit.*, p. 84, figs. 46, 47.
1891. *Eurytemora affinis*, Brady, Revision Brit. F.-W. Cyclop. and Calanid., p. 42, pl. xiii., figs. 6-9.

Habitat.—Forth, about Culross and Alloa. Common.

Family CYCLOPIDÆ.

Genus Cyclops, Müller (1785).

Cyclops signatus, Koch.

1841. *Cyclops signatus*, Koch, Deutschlands Crustaceen, etc., H. 21, tab. viii. (antenna with serrated ridge).
1857. *Cyclops tenuicornis*, Claus, Weigmann's Archiv., p. 21, pl. iii., figs. 1-11 (antenna with simple ridge).
1891. *Cyclops signatus*, Brady, *op. cit.*, p. 6, pl. ii., fig. 5.

Habitat.—Duddingston Loch (ridge simple); Cocklemill Burn, near Largo (ridge simple and serrated); Raith Lake (ridge simple); Loch Leven (ridge simple); Lochgelly Loch (ridge simple); Kinghorn Loch (ridge simple); pools at Luffness Links (ridge simple).

Cyclops strenuus, Fischer.

1851. *Cyclops strenuus*, Fischer, Bull. Soc. imp. Moscou., p. 419, pl. ix., figs. 12-21.
1891. *Cyclops strenuus*, Brady, *op. cit.*, p. 8, pl. ii., figs. 1-4.

Habitat.—Loch Leven, Kinross-shire, common; Loch Fitty, Fifeshire; Cocklemill Burn, near Largo.

Cyclops vicinus, Uljanin.

1875. *Cyclops vicinus*, Uljanin, Crustacea of Turkestan, p. 30, pl. x., figs. 1-7; pl. xii., figs. 7-9.
1878. *Cyclops pulchellus*, Brady, Mon. Brit. Copep., p. 107, pl. xvii., figs. 1-3.
1891. *Cyclops vicinus*, Brady, Revision Brit. F.-W. Cyclop. and Calanid., p. 12, pl. i., figs. 6-9.

Habitat.—Loch Leven, Kinross; Cocklemill Burn, near Largo; Kinghorn Loch, Fifeshire.

Cyclops bicuspidatus, Claus.

1857. *Cyclops bicuspidatus*, Claus, Weigmann's Archiv., p. 209, pl. xi., figs. 6, 7.
1891. *Cyclops bicuspidatus*, Brady, *op. cit.*, p. 13, pl. v., figs. 1-5.

Habitat.—Duddingston Loch.

Cyclops thomasi, Forbes.

1882. *Cyclops thomasi*, Forbes, American Naturalist, vol. xvi., p. 640, pl. ix., figs. 10, 11, 16.
1891. *Cyclops thomasi*, Brady, *op. cit.*, p. 15, pl. vi., figs. 1-4.

Habitat. — Duddingston Loch, Lochgelly Loch, Camilla Loch.

Cyclops viridis (Jurine).

1820. *Monoculus quadricornis viridis*, Jurine, Hist. des Monoc., p. 46, pl. iii., fig. 1.
1857. *Cyclops brevicornis*, Claus, Weigmann's Archiv., pl. iii., figs. 12-17.
1857. *Cyclops gigas*, *ibid.*, p. 207, pl. xi., figs. 1-5.
1891. *Cyclops viridis*, Brady, *op. cit.*, p. 17, pl. v., figs. 6-10.

Habitat.—Generally distributed throughout the district. Duddingston Loch; Loch Leven, Kinross-shire; etc.

Cyclops serrulatus, Fischer.

1838. *Cyclops serrulatus*, Fischer, Bull. Soc. imp. Moscou., p. 423 pl. x., figs. 22, 23, 26-31.
1891. *Cyclops serrulatus*, Brady, *op. cit.*, p. 18, pl. vii., fig. 1.

Habitat.—Generally distributed throughout the district. Colour of ovisacs very variable—blue, reddish, green.

Cyclops affinis, G. O. Sars.

1863. *Cyclops affinis*, G. O. Sars, Videnskabsselsk. Forhandl., 1862, p. 47.
1891. *Cyclops affinis*, Brady, *op. cit.*, p. 21, pl. viii., figs. 1-6.

Habitat.—Raith Lake, Kirkcaldy; Black Loch, near Loch Glow, Kinross-shire.

Cyclops ewarti, G. S. Brady.

1888. *Cyclops ewarti*, Brady, Sixth Annual Report of the Fishery Board for Scotland, p. 232, pl. viii. figs. 1-6.
1891. *Cyclops ewarti*, Brady, Revision Brit. F.-W. Cyclop. and Calanidæ, p. 22, pl. vii., figs. 4-7.

Habitat.—Forth estuary, west of Queensferry, near the mouth of the Ironmill Burn. (Loch Morar, a fresh-water loch in Inverness-shire.)

Cyclops phaleratus, Koch.

1841. *Cyclops phaleratus*, Koch, Deutschlands Crustaceen, etc., H. 21, tab. ix.
1891. *Cyclops phaleratus*, Brady, *op. cit.*, p. 25, pl. ix., fig. 2.

Habitat.—Duddingston Loch; Raith Lake, Kirkcaldy; Black Loch, near Loch Glow, Kinross-shire.

Cyclops fimbriatus, Fischer.

1785. *Cyclops crassicornis*, Müller, Entomostraca, p. 113, pl. xviii., figs. 15-17.
1853. *Cyclops fimbriatus*, Fischer, Bull. Soc. imp. Moscou., p. 94, pl. iii., figs. 19-28, 30.
1878. *Cyclops crassicornis*, Brady, Mon. Brit. Copep., vol. i., p. 118, pl. xxiii., figs. 1-6.
1891. *Cyclops fimbriatus*, Brady, Revision Brit. F.-W. Cyclop. and Calanidæ, p. 25, pl. ix., fig. 1.

Habitat.—Generally distributed throughout the district. Duddingston Loch; in a small spring among the rocks on the side of Arthur's Seat above the "Targets"; Raith Lake, Kirkcaldy; Loch Fitty; ditch in the vicinity of Harelaw Dam, Balerno, near Edinburgh, etc.

Cyclops æquoreus, Fischer.

1860. *Cyclops æquoreus*, Fischer, *op. cit.*, p. 654, pl. xx., figs. 26-29.
1878. *Cyclops æquoreus*, Brady, Mon. Brit. Copep., vol. i., p. 119, pl. xix., figs. 8-10; pl. xxi., figs. 10-17.
1891. *Cyclops æquoreus*, Brady, Revis. Brit. F.-W. Cyclop. and Calanidæ, p. 26, pl. x., fig. 1.

Habitat. — Brackish-water pools at high-water mark, Cramond Island, Firth of Forth.

Family HARPACTICIDÆ.

Genus **Canthocamptus**, Westwood (1836).

Canthocamptus minutus (Müller).

1776. *Cyclops minutus*, Müller, Zool. Dan. Prod., Entom., p. 101, pl. xvii., figs.

1785. *Cyclops minutus*, idem, Entom., p. 101, pl. xvii., figs. 1-7.

1850. *Canthocamptus minutus*, Baird, Brit. Entom., p. 204, pl. xxv., figs. 4-8; pl. xxx., fig. 3.

1880. *Canthocamptus minutus*, G. S. Brady, Brit. Copep., vol. ii., p. 48, pl. xliv., figs. 1-17.

Habitat.—Generally distributed throughout the district. Duddingston Loch, frequent; Black Loch and Lurg Loch, near Loch Glow, Kinross-shire; Camilla Loch, Raith Lake, and Lochgelly Loch, Fifeshire; Loch Leven, Kinross-shire. Ovisac large, pale blue.

Canthocamptus northumbricus, Brady.

1880. *Canthocamptus northumbricus*, Brady, *op. cit.*, vol. ii., p. 57, pl. xlv., figs. 1-14.

Habitat.—Duddingston Loch. This is distinguished from *Canthocamptus minutus* by the inner branches of the second, third, and fourth pairs of swimming feet being two-jointed. It is also smaller. The second and third joints of the inner branches of the first swimming feet are proportionally shorter. Ovisac smaller, proportionally; colour whitish, with a tinge of red.

Canthocamptus palustris, Brady.

1880. *Canthocamptus palustris*, Brady, Mon. Brit. Entom., vol. ii., p. 53, pl. xxxix., figs. 13-23.

Habitat.—Pools on May Island, August 1890.

Genus **Attheyella**, Brady (1880).

Attheyella spinosa, Brady.

1880. *Attheyella spinosa*, Brady, *op. cit.*, vol. ii., p. 58, pl. xliii., figs. 15-18; pl. xlvi., figs. 13-18.

Habitat.—Duddingston Loch; Kilconquhar Loch; Black Loch, near Dunbar; Lochgelly Loch; Loch Leven, Kinross, frequent. In this species both branches of the first pair of swimming feet are three-jointed, and of nearly equal length.

Attheyella cryptorum, **Brady.**

1868. *Canthocamptus cryptorum*, Brady, Jour. Microscop. Soc., vol. ix., pl. vi., figs. 1-10.
1880. *Attheyella cryptorum*, Brady, Mon. Brit. Entom., vol. ii., p. 60, pl. lii., figs. 1-18.

Habitat.—Duddingston Loch; in a ditch in the vicinity of Harelaw Dam, Balerno, near Edinburgh. Apparently rare.

VII. *Results of Meteorological Observations taken at Edinburgh during* 1892. By R. C. MOSSMAN, Esq., F.R.Met.Soc., F.R.S.E.

(Read 18th January 1893.)

The observations under discussion are those taken during the past year at the Edinburgh Station of the Scottish Meteorological Society, situated in the south side of the city, at an elevation of 254 feet above mean sea-level. The distance from the sea is about 2 miles. Observations have now been made at this station since 1886. It may be mentioned in passing that all the meteorological observations for the thirty years previous, or since the establishment of the Scottish Meteorological Society, were taken at stations within half a mile from the present site, and at the same altitude, so that the disturbing influences arising from difference of elevation, or change of position, or in the exposure of the instruments, are eliminated, when we come to compare the earlier series of observations with those made during recent years. During the past year, as in previous ones, barometer readings have been taken twice a day, at 9 A.M. and 9 P.M.; those of the self-registering thermometers (maximum and minimum) at 9 P.M. for the preceding 24 hours, those of the rainfall every morning at 9, and those of the hygrometer and wind twice a day, at 9 A.M. and 9 P.M.

Complete copies of the observations taken have been supplied monthly to the Scottish Meteorological Society, and the Meteorological Office, London, and weekly returns of temperature and rainfall to the Registrar-General, similar weekly returns of bright sunshine being sent to the Meteorological Office. Monthly and yearly rainfall reports are supplied to Mr Symons for his annual work on British Rainfall. The instruments in use are as follows:—

Barometers.—The standard barometer is a Kew marine, which has a tube 0·5 inch in diameter, and is read by means of a vernier directly to 0·002 inch. Another barometer of the same description is kept as a reserve instrument. Continuous traces of pressure oscillations are furnished by two barographs, one a mercurial instrument by Redier of Paris, the other being one of the well-known Richard aneroids. One of the Watkin patent aneroid barometers is also kept as a reserve instrument. For an aneroid it is remarkably accurate.

Thermometers and Hygrometers.—These are exposed in a double louvred Stevenson screen, at a height of 4 feet above grass, and consist of maximum and minimum registering thermometers and a Mason's hygrometer. Duplicates of these instruments are kept in reserve. A thermograph, by Richard Brothers of Paris, gives a continuous record of temperature fluctuations, corresponding values of relative humidity being obtained from a hygrograph by the same makers.

Radiation Thermometers.—For the registration of solar radiation, a maximum thermometer in *vacuo*, with the bulb and part of the stem blackened, is employed. The difference between the indications of a registering minimum thermometer freely exposed on the surface of the grass, and a similar thermometer in the shade 4 feet above it, gives a measure of the intensity of terrestrial radiation.

Rain Gauges.—Two of these are in use, the standard being a copper cylinder, 14 inches deep, with a turned brass rim 5 inches in diameter. One of Symon's storm rain gauges is in use from April to October for the direct observation of thunderstorm and other torrential rains.

Anemometer and Wind Vane.—A Robinson hemispherical cup anemometer and wind vane are placed on the top of a ladder erection at a height of 17 feet above the ground. Owing to the somewhat sheltered position, the results are only of comparative value, although, for a town, the situation is about as good as could be obtained.

Sunshine.—A Campbell-Stokes sunshine recorder gives a continuous record of bright sunshine whenever the sun shines. Owing to smoke from the city, fully 10 per cent. of the possible sunshine is lost, even on practically cloudless days, it being a well-known fact that the instrument ceases to record when the sun shines through smoke-haze, or thin cirri-form clouds.

Rainband.—Observations on the thickness of the rainband in the spectrum of sunlight are generally made thrice daily, viz., at 9 A.M., noon, and 3 P.M.; an extra observation being made at 6 P.M. when the state of the light permits. The instrument used is one of Hilger's direct vision spectroscopes.

Miscellaneous Observations.—A Stephanome, invented by Professor Tait, is employed for the angular measurements of halos, coronæ, etc. Since last year (1892) one of Aitken's dust counters and a koniscope have been added to the stock of instruments, regular observations being at present in progress. In addition to the above, non-instrumental observations of the direction and force of the wind, amount, form, and species of cloud, etc., are made daily. The instruments, of which the foregoing is a brief description, have, with few exceptions, been compared with the standard instruments at the Kew Observatory, an additional check being the annual inspection of the station by Dr Buchan, in the autumn of each year.

REMARKS ON THE METEOROLOGY OF 1892.

January.—Dry and sunny weather were the prominent features of the meteorology of this month. During the first three weeks, temperature was uniformly low, and slight showers of snow and soft hail were of frequent occurrence.

During the last week the temperature rose rapidly, with freshening west and south-west winds, which blew with the force of a moderate gale on the 28th and 29th. The finest weather was from the 14th to the 16th, 14½ hours bright sunshine being recorded, although a considerable amount was lost owing to thick haze, which invariably accompanies anti-cyclonic conditions throughout the winter. This sunny period was succeeded by a week's dull weather, no sunshine being recorded during the week ending the 23rd, during which time showers were of frequent occurrence.

February.—The month opened with strong westerly breezes and low pressure, the minimum for the month being recorded on the 2nd. During the first fortnight, temperature kept well above the mean, accompanied by a good deal of bright sunshine. On the 13th, pressure reached its maximum for the month, this being accompanied by easterly winds, which blew persistently till the close of the month. Temperature during this period remained low, showers of snow and hail being of frequent occurrence. Little sunshine was recorded.

March.—Northerly and easterly winds blew well-nigh persistently throughout the greater part of March, the accompanying weather being cold and unsettled, although sunshine was abundant. The month opened with high barometric pressure and frequent auroral displays, although with dull weather, only 9 hours' sunshine being recorded in the first week; dry weather, however, prevailed, no precipitation being noted in the period under consideration. During the second week wintry weather was experienced, snow falling daily, while pressure fell to a minimum on the 9th, and kept well below the mean till the 18th. During the remainder of the month, although cold weather largely predominated, there were a few brief intervals of warmth, accompanied by a considerable amount of sunshine and but little rainfall. With the exception of a severe snowstorm on the 26th, which yielded 0·44 inch of water, no really bad weather was experienced.

April.—The outstanding feature of the meteorology of this month was the large amount of bright sunshine, 162 hours being recorded. During the first half of the month, when easterly and north-easterly winds prevailed, there was a considerable number of dull days, although little rain fell. Temperature on the 2nd rose to 68°, rising above 60° on the first four days of the month. The second half of the month was fine and sunny, although snow showers were of somewhat frequent occurrence. Pressure was high and steady, and there was no storm of importance.

May.—During the first half the barometer was high and steady, accompanied by little rainfall, and three-fifths of the total sunshine; but on the 14th the barometer fell quickly, and reached the minimum for the month on the 16th. During the second half of the month rain fell almost daily, and the weather was generally unsettled. Temperature up till the 23rd of the month was, on the whole, below the average, but thereafter kept well above it. No gales were experienced.

June.—Cyclonic conditions prevailed throughout the greater part of June, the only really fine weather experienced being on the 7th, 8th, and 9th, the maximum temperature recorded on these days being 70°·9, 75°·8, and 80°·1 respectively. On no other day of the month did the temperature reach 70°. Sunshine was on the whole abundant, although heavy rains were of common occurrence.

July.—The prominent features of the weather of this month were, a mean temperature considerably below the average, with an almost entire absence of warm weather, and a rainfall considerably below the normal. Little sunshine was, however, recorded. During the first week rather stormy weather was experienced, pressure falling to a minimum on the 7th, rain descending daily from the 2nd to the 7th of the month. Up to the 19th pressure deviated but little from the normal, the weather remaining dry, with light easterly winds; but on the 18th and 19th pressure gave way, rain coming down heavily. On the 20th an anti-cyclone advanced from the westward, this being accompanied by dull, cloudy, but dry weather.

August.—Throughout the greater part of August unsettled and showery weather largely predominated, although sunshine was fairly abundant. Although temperature was but a third of a degree below the normal, there were only two days on which 70° was reached. Except for a few days during the second week, when the barometer rose above 30 inches, pressure was below the mean, the range, however, being small. The finest weather occurred about the middle of the month, the 14th and 15th having over 10 hours' sunshine. This was followed by the dullest weather experienced during the month, only 22 hours' sunshine being recorded in the 6 days ending the 22nd.

September.—Throughout the greater part of this month winds from a westerly quarter prevailed, producing showery and generally unsettled weather, although the total rainfall was less than half the average. Temperature was fully two degrees below the normal, and never rose above 64°·5, a very low maximum for this month. Sunshine, owing to the cloudy conditions accompanying the westerly winds, was scanty, no day being really fine, the sunniest being the 17th, when 8 hours was recorded.

October.—This month was relatively one of the coldest of the whole year, temperature falling, on the mean, 3°·7 below the average. Rainfall was considerably above the normal, the month being the wettest October since 1886, when the precipitation was slightly greater. In the first 3 weeks only 27 hours' sunshine was recorded, there being 12 days on which the amount registered was less than 1 hour. The first snow of the season fell on the 23rd. The rainfall on the 3rd, viz., 0·92 inch, was the greatest daily fall throughout the year.

November.—Mild weather prevailed throughout the whole of this month, temperature on no occasion falling below 30°·1 in the shade. On the other hand, temperatures exceeding 50° were recorded on no less than 12 days. Sunshine was about the average, but there was no day on which more than four hours was recorded. There was, however, no period characterised by very dull weather. The only snowfall of the month occurred on the 30th.

December.—The month opened with a heavy snowstorm and cold weather, the maximum temperature on the 2nd being 30°·1. During the first fortnight cold, wintry weather was experienced, barometric pressure being very unsteady.

This was followed by a week of mild weather, temperature rising to 52°·0 on the 17th and 53°·1 on the 18th. During this week rather strong westerly winds were experienced. On the 20th, easterly winds set in, continuing till the end of the month. Very cold weather occurred in the last week, the maximum on the 25th being only 26°·1. No precipitation was noted between the 22nd and the 30th. This was the coldest December since 1882, the mean temperature being 34°·8, or 4° below the average. Colder Decembers were the following:—

Year.	Temp.	Year.	Temp.	Year.	Temp.
1882	33°·6	1846	34°·4	1815	34°·1
1878	31°·0	1844	33°·0	1801	32°·5
1874	32°·0	1819	34°·0	1799	34°·3

1796, mean temperature 31°·0.

On the other hand, the mildest December was that of 1843, when the mean temperature was 47°·7.

NOTEWORTHY PHENOMENA IN THE METEOROLOGY OF 1892.

Highest barometric reading 30·621 inches, on March 22nd, at noon.

Lowest barometric reading 28·708 inches, on February 2nd, at 5 A.M.

Highest temperature in shade 80°·1, on June 9th, at 1 P.M.

Lowest temperature in shade 14°·0, on February 19th, at 5 A.M.

Greatest daily range of temperature 33°·1, on April 2nd.

Least daily range of temperature 3°·0, on October 13th.

Highest temperature in sun's rays 131°·5, on August 3rd.

Greatest excess of sun maximum over shade maximum, 76°·8, on March 27th.

Lowest temperature on grass 8°·7, on December 2nd.

Greatest difference between minimum on grass and shade, 12°·0, on April 5th.

Stormiest day January 29th, mean wind velocity 23 miles per hour.

Sunniest day June 9th, with 14 hours 38 minutes sunshine.

Greatest daily rainfall 0·92 inch, on October 3rd.

	Barometer at 32° and Sea-Level.					Temperature in Shade 4 Feet above Grass.									Relative Humidity Saturation=100.		
	Mean.	Diff. from Average.	Highest.	Lowest.	Range.	Mean.	Diff. from Avge.	Highest	Lowest.	Monthly Range.	Mean of Maxim	Mean of Minim	Mean Daily Range.	Greatest Daily Range.	Mean.	Max.	Min.
	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°	°	°	°	%	%	%
January, .	29·744	– ·056	30·411	29·150	1·261	36·6	– 1·9	52·6	24·8	27·8	40·8	32·4	8·4	13·4	82	98	63
February,	29·776	– ·069	30·619	28·708	1·911	37·4	– 2·2	52·3	14·0	38·3	42·3	32·6	9·7	18·2	86	98	53
March, .	30·055	+ ·235	30·621	29·188	1·433	37·4	– 2·8	63·2	21·6	41·6	43·7	30·9	12·8	26·0	79	99	34
April, . .	30·012	+ ·110	30·457	29·454	1·003	43·8	– 1·0	68·0	26·0	42·0	52·0	35·7	16·3	33·1	76	98	30
May, . .	29·926	– ·021	30·499	29·297	1·202	50·8	+0·8	69·9	36·0	33·9	58·6	43·1	15·5	26·0	75	100	39
June, . .	29·940	+ ·019	30·383	29·258	1·125	54·4	– 0·3	80·1	37·8	42·3	62·0	46·8	15·2	25·3	78	96	41
July, . .	29·996	+ ·096	30·384	29·168	1·216	55·9	– 2·2	71·8	43·4	28·4	62·4	49·4	13·0	25·5	80	97	46
August, .	29·808	– ·066	30·255	29·209	1·047	57·2	– 0·2	71·3	39·2	32·1	63·8	50·5	13·3	24·7	81	98	45
September,	29·800	– ·052	30·377	29·221	1·156	51·9	– 2·1	64·5	38·2	26·3	58·2	45·6	12·6	20·0	78	97	44
October, .	29·700	– ·112	30·379	28·820	1·559	43·8	– 3·7	59·8	25·9	33·9	49·1	38·6	10·5	18·6	80	99	44
November,	29·921	+ ·069	30·437	29·249	1·188	43·1	+ 1·6	55·3	30·1	25·2	48·1	38·1	10·0	19·1	84	97	56
December,	29·891	+ ·070	30·272	29·145	1·127	34·8	– 4·0	53·1	16·9	36·2	39·4	30·2	9·2	18·8	84	99	57
Year, . .	29·881	+ ·018	30·621	28·708	1·913	45·6	– 1·5	80·1	14·0	66·1	51·7	39·5	12·2	33·1	80	100	30

	Solar Radiation.				Terrestrial Radiation.				Rainfall.				Cloud 0–10.		
	Max. in Sun.	Mean.	Average excess over Shade Maxim.	Greatest excess over Shade Maxim.	Minim. on Grass.	Mean.	Average Diff. from Shade Minim.	Greatest Diff. from Shade Minim.	Total.	Diff. from Average.	No. of Rainy Days.	Maxim. Fall in 24 hours.	9 A.M.	9 P.M.	Mean.
	°	°	°	°	°	°	°	°	Inches.	Inches.		Inches.			
January, . .	71·5	54·3	13·5	31·0	20·2	28·2	-4·2	7·3	1·05	-1·38	12	0·21	6·3	6·5	6·4
February, .	92·3	75·0	32·7	53·8	14·1	29·0	-3·6	8·5	2·00	+0·04	22	0·42	7·4	4·9	6·2
March, . .	110·0	87·9	44·0	76·8	17·3	27·8	-3·8	8·0	1·37	-0·60	11	0·44	5·2	5·7	5·4
April, . . .	119·3	101·4	49·4	62·8	21·0	31·8	-3·9	12·0	1·11	-0·95	11	0·32	6·0	5·3	5·6
May, . . .	130·1	110·6	52·0	67·7	27·8	39·0	-4·1	10·0	3·00	+0·91	18	0·60	8·0	6·5	7·2
June, . . .	127·2	112·4	50·4	61·3	33·3	44·6	-2·2	5·7	3·14	+1·04	18	0·52	7·9	6·9	7·4
July, . . .	129·0	111·1	48·7	63·9	40·1	47·4	-2·0	4·7	1·17	-2·19	12	0·32	8·3	7·7	8·0
August, . .	131·5	110·2	46·4	63·6	34·9	47·4	-3·1	5·9	4·80	+1·32	19	0·85	7·4	6·2	6·8
September, .	118·3	101·4	43·2	57·5	33·3	41·6	-4·0	6·8	1·20	-1·72	16	0·18	7·3	5·1	6·2
October, . .	104·6	75·3	26·2	48·6	21·2	34·7	-3·9	6·8	3·92	+1·52	19	0·92	5·8	6·8	6·3
November, .	93·5	63·8	15·7	47·2	22·8	32·4	-5·7	9·7	1·43	-1·21	19	0·21	5·8	5·4	5·6
December, .	64·5	45·4	6·0	23·1	8·7	25·5	-4·7	9·8	1·36	-1·12	13	0·29	5·8	5·3	5·6
Year, . . .	131·5	87·4	35·7	76·8	8·7	35·8	-3·7	12·0	25·55	-4·34	190	0·92	6·8	6·0	6·4

	Hourly Values of Bright Sunshine.																	Bright Sunshine.			Horizontal Air Movement.		
	A.M.								P.M.								Total.	Per Cent. of possible Duration.	Greatest in one Day.	Days with none.	Total.	Mean Velocity per Hour.	Greatest in 24 Hours.
	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9to10	10to11	11 to Noon.	Noon to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8							
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.		Hrs.		Miles.	Miles.	Miles.
January, .	...	...	...	...	...	1·47	8·27	10·32	9·61	6·85	6·07	0·47	...	...	...	...	43·1	18	5·4	13	5,960	8·0	541
February, .	...	...	...	...	0·50	1·74	10·61	11·86	10·85	10·02	9·81	5·53	0·95	...	...	...	61·9	23	6·6	5	4,082	6·0	437
March, . .	...	...	1·53	5·25	9·32	13·78	14·90	15·48	12·74	13·80	12·15	10·93	8·56	3·37	...	...	121·8	33	10·8	5	3,739	5·0	275
April, . .	...	2·41	6·67	8·97	13·96	14·85	15·37	16·28	16·28	16·67	16·05	14·72	10·23	7·10	1·97	...	161·6	38	11·6	2	3,816	5·3	486
May, . .	1·20	3·48	5·50	6·11	8·25	13·42	15·17	15·28	15·47	17·27	16·39	14·50	11·98	10·37	6·02	0·41	160·8	32	12·6	3	5,148	7·0	415
June, . .	2·17	7·17	8·32	10·32	9·07	9·65	12·97	15·69	14·80	15·10	14·85	12·41	12·11	13·13	11·67	6·00	175·4	34	14·6	2	3,498	4·8	328
July, . .	1·30	2·65	5·45	5·60	6·98	7·44	7·67	9·93	9·65	10·15	9·42	9·60	10·42	13·20	8·36	2·44	120·3	23	12·8	2	4,132	5·5	401
August, .	0·19	4·02	10·10	12·50	13·78	14·39	12·97	13·61	13·15	13·60	12·03	10·85	8·75	8·07	3·50	0·15	151·6	33	11·9	4	4,634	6·2	315
September,	...	...	0·53	4·88	6·94	8·05	9·58	10·30	11·90	11·74	11·07	11·75	7·90	4·30	0·72	...	99·7	26	8·0	3	5,669	7·9	445
October, .	...	...	...	0·27	1·32	4·98	9·75	10·64	10·28	12·34	10·03	4·42	0·47	...	...	...	64·5	20	6·4	8	3,808	5·1	300
November,	...	...	...	...	...	1·61	6·88	8·22	8·23	6·74	5·17	2·91	0·61	...	...	...	40·4	16	4·2	11	3,743	5·2	504
December,	...	...	...	...	...	1·50	4·53	9·45	10·83	8·91	2·08	...	...	...	...	...	37·3	17	5·0	18	3,109	4·2	370
Year, . .	4·86	19·73	38·10	53·90	70·12	92·88	128·67	147·06	143·79	143·19	125·12	98·09	71·98	59·54	32·24	9·00	1238·4	28	14·6	76	51,338	5·8	541

	Wind from Observations made at 9 A.M. and 9 P.M. Number of Times it blew from certain directions.											Number of Times certain Phenomena were observed.												
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.	Force 0-12.	Mean Rainband, Scale 0-6.	Solar Halos.	LunarHalos.	Rainbows.	Thunder-storms.	Lightning.	Aurora.	Snow.	Hail.	Frost in shade.	Frost on grass.	Mist.	Mist on Arthur'sSeat	Gales.
January,	1	1	3	5	4	5	31	7	5	1·18	1·16	9	9	0	1	0	0	6	4	15	23	0	0	2
February,	4	4	10	2	3	0	20	6	9	0·72	1·16	3	0	0	1	0	0	8	4	11	19	3	6	0
March,	0	6	12	8	5	11	8	9	3	0·69	0·95	4	2	0	0	0	3	10	4	21	26	0	0	0
April,	6	6	17	1	2	3	20	2	3	0·76	1·22	3	0	1	0	0	0	5	4	7	16	1	4	1
May,	1	3	19	0	1	6	23	4	5	1·08	1·28	0	0	0	0	0	1	0	0	0	7	2	5	0
June,	5	3	13	2	3	3	24	2	5	0·92	1·19	1	0	2	1	0	0	0	2	0	0	0	3	1
July,	1	1	25	1	0	1	29	0	4	1·01	1·24	3	2	3	0	0	0	0	0	0	0	1	6	1
August,	0	1	11	2	0	5	38	1	4	0·99	1·30	2	0	2	1	0	0	0	2	0	0	1	7	1
September,	1	0	5	1	3	6	41	1	2	1·27	1·10	2	1	0	0	0	2	0	0	0	0	0	0	3
October,	7	2	7	3	3	5	31	3	1	0·94	1·14	1	1	0	1	0	1	1	1	4	10	0	0	2
November,	0	1	7	10	10	6	19	1	6	1·00	1·27	0	2	0	0	0	1	1	0	4	16	0	1	2
December,	4	3	7	3	2	4	25	4	10	0·82	1·00	0	2	0	0	1	0	2	0	19	23	1	1	1
Year,	30	31	136	38	36	55	309	40	57	0·95	1·17	28	19	8	5	1	8	33	21	81	140	9	33	14

VIII. *A further Description of* Palæospondylus Gunni, *Traquair.* By R. H. TRAQUAIR, Esq., M.D., LL.D., F.R.S. [Plate I.]

(Read 18th January 1893.)

Palæospondylus Gunni is the name which I gave, a little more than two years ago,[1] to a strange little vertebrate organism from the Old Red Sandstone of Achanarras, Caithness, the original discovery of which we owe to Dr Marcus Gunn and his cousin, Mr Alexander Gunn. It is a very small creature, usually under an inch in length, showing a head and vertebral column, but neither jaws nor limbs, and, when first discovered, was supposed by some who saw it to be possibly a young condition of *Coccosteus*. Concerning its affinities, I expressed myself as follows :—

"It is very difficult to give an opinion on the affinities of this strange little organism, except that it is a vertebrate, and probably a fish. It is certainly not a Placoderm, its resemblance to a supposed 'baby *Coccosteus*' being entirely deceptive. The appearance of the head does remind us in a strange way of the primitive skull of *Myxine*, a resemblance which is rendered still more suggestive by the apparent complete absence of lower jaw or limb-girdles. But a Myxinoid with ossified skeleton, including differentiated vertebral centra, is, it must be owned, a rather startling idea!"

Undoubtedly this is a startling idea—but the Marsipobranch theory of its affinities has found favour with at least two morphologists who have had the opportunity of examining the original as well as other specimens. Professor G. B. Howes,[2] of the Royal College of Science, writes: "The palæontological history of the Marsipobranchii, until lately estimated upon the supposition that the conodonts, some of which have been claimed as annelide jaws, are Marsipobranch teeth, has recently undergone a revolution, in Traquair's description of a very remarkable fossil from the Old Red Sandstone at Caithness, which he has named *Palæospondylus Gunni*, after its discoverer. . . . I fully acquiesce in his having provisionally referred the creature to a Marsipobranch affinity. . . . There appears to me no inherent objection to referring the animal to a kinship with the Hags, merely because its skeleton was superficially calcified, especially if Dohrn's views of the origin of Cyclostomata by degradation from a truly gnathostomous type, and if Walcott's recently alleged discovery of a Chimæroid notochord in the Ordovician strata, should ultimately prove correct."

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[1] Ann. and Mag. Nat. Hist. (6), vol. vi., 1890, p. 485, fig. 4.

[2] Trans. Biol. Soc. Liverpool, vol. vi., pp. 143, 144.

The other writer is Mr Smith Woodward, who has furnished some notes regarding this organism, as well as a "restored" sketch embodying his idea of its structure.[1] Concerning its affinities, he remarks:—"It *seems* to possess an unpaired nose, lip cartilages in place of functional jaws, and no paired limbs; thus agreeing precisely with the lampreys and hagfishes, of which the fossil representatives have long been sought. Theoretically speaking, allies of these limbless Chordata ought to have been a dominant type in the late Silurian and early Old Red Sandstone age; and it is a well-known law that animals, when dominant, attain to a higher degree of development than at any other time in their history. It is extremely probable, therefore, that *Palæospondylus* belongs to this interesting category."

Mr Woodward, indeed, goes so far as to see, in the head of *Palæospondylus*, "a great broad ring crushed upon the anterior part of the skull," which "bears an extraordinary resemblance to the annular cartilage forming the rim of the mouth in the lamprey." If there is no mistake here, we should certainly expect to find other points of correspondence of an equally interesting character between the skulls of *Palæospondylus* and *Petromyzon*, and the affinities of the former with the living Marsipobranchs must be very much closer than I ever imagined them to be when I first hazarded the suggestion of such an alliance.

Since my first notice of *Palæospondylus* was published, I have examined a considerable number of additional specimens, some of which were collected by myself and my friend Mr John Gunn; others, and among these the beautiful specimen represented in Pl. I., Fig. 1, I obtained from Mr Donald Calder of Thurso.

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[1] Natural Science, vol. i., No. 8, October 1892, p. 597, fig. 1.

It must first be noted that all the specimens seem to lie on their backs in the stone, the ventral aspect of the head only being exposed: where the vertebral column is well preserved, this can be verified by observing the relation of the neural arches to the centra, as shortly behind the head the column is ordinarily twisted so as to lie on its side (Woodcut, p. 90). These facts indicate that the head not only was flattened, but that the upper or dorsal aspect had irregularities causing it to adhere more closely to the matrix. Secondly, we must bear in mind that almost every specimen which has occurred has the skull in a more or less abraded condition. The specimens are not conspicuous except upon weathered surfaces, and then it will be found that the weathering has eaten more or less through the surface of the head, so as to produce an appearance naturally subject to some variation in different individuals. The substance of which the remains consists is black, and of the appearance of jet; I have not examined it microscopically,[1] but under a simple lens it presents no trace of structure.

Fig. 2, Pl. I., represents the most uninjured head which I have ever obtained, and which is here, as usual, looked at from the ventral surface. It is oblong, divided by a constriction on each side into anterior and posterior parts, each of a somewhat hexagonal shape. The anterior part (Woodcut, *t.p.*) has a narrow anterior margin, and a broader posterior one where it joins the hinder division; on each side there are two lateral margins, joining each other in an obtuse external angle. The surface of this division of the cranium is gently convex, with a median longitudinal depression or furrow, the edges of which are somewhat prominent. The surface on each side is not smooth, but shows several pitted markings radiating somewhat from each external angle. Each antero-lateral angle is produced into an anteriorly directed pointed feeler-like process, reminding us indeed of the prepalatine process of *Myxine*, but an examination of other specimens (see Figs. 1 and 4) shows that there were at least two other similar but shorter points projecting forward from the anterior margin of the skull (Woodcut, *c.*). The posterior division of the skull (Woodcut, *p.a.*) is flatter than the anterior, but the median furrow or groove is still observable, though not so sharply defined.

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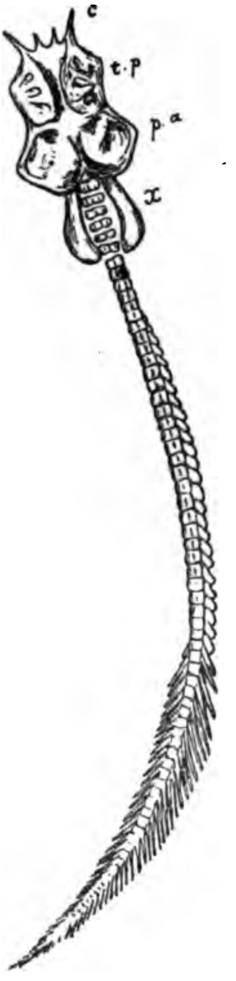
[1] The fish remains, in general, which occur in the Caithness flags, are quite useless for microscopic work, owing to the tissue being saturated with opaque black bituminous matter.



Palæospondylus Gunni, Traq. Magnified restored outline, the head seen from the ventral surface. *c*, cirrhi; *t.p.*, anterior part of cranium; *p.a.*, posterior part of cranium; *x*, paired plate-like structure behind the head.

The most natural interpretation of these appearances seems to be this, —that we have here a primitive cranium composed of calcified cartilage, as there are no reliable evidences of discrete ossifications, —that the posterior part represents the parachordal elements fused with the ear capsules, while the anterior part consists of the trabeculæ, fused with an element on each side representing the palatine cartilage of the lamprey — and that the anterior border of the head, with its four points or cirrhi, represents the upper margin of a suctorial mouth. There seems to be no basicranial fontanelle.

I have already said that in almost every case the surface of the head is more or less eroded and broken through, and the effects of this wearing are seen in Figs. 1, 4, and 5. Naturally the more prominent parts on each side of the median groove are the first to go, and consequently the circumference of the anterior part of the skull is apt to remain in a ring-like form, while the rest is more or less worn away. That this is the origin of the appearance interpreted by Mr Smith Woodward as an oral ring, and compared by him to the annular cartilage of the lamprey, there can be no manner of doubt. The supposed ring is the result of weathering, so that the resemblance between *Palæospondylus* and *Petromyzon* is not quite so close as the presence of such a structure would have led us to suppose.

Nevertheless, the total absence of any trace of lower jaw, together with the entire appearance of the cranium, is highly suggestive of the idea that we have here to deal with an agnathous suctorial vertebrate, related in some way to the modern Marsipobranchii. What of the organs of special sense?

There can be no reasonable doubt that the lateral parts of the hinder moiety of the cranium enclosed the auditory organs. In Fig. 1, what I suppose to be the auditory capsules are shown broken into at various places by the process of weathering. The ventral convexity of the lateral parts of the anterior half of the skull, of the part on each side which I have compared to the palatine cartilage of the lamprey, most probably also corresponds to the position of the eye. When these convexities are worn away, as in Figs. 1, 4, and 5, what seems to remain of the front part of the skull is a comparatively narrow portion traversing antero-posteriorly the space enclosed by the now ring-like circumference, and dividing that space into two smaller and lateral spaces, which at first sight one might be tempted to look upon as paired nasal chambers. But these seem to me to be certainly only the orbits broken into from below, and consequently I here agree with Mr Woodward, that there is "no certain evidence of nasal capsules." Consequently it is not impossible that the nasal organ was single, as in recent Marsipobranchii.

Immediately behind the head there is an appearance which I at first interpreted as a small median shield covering the first half dozen vertebræ on the dorsal aspect (see Fig. 2; also *x* in Woodcut), in which interpretation Mr Woodward also seems to concur. But since I wrote my previous notice I have examined several specimens, for example that represented in Fig. 1, in which it is plain that the supposed median shield consists of two narrow lateral pieces, which may be divaricated at an angle from each other. Ordinarily, however, the two pieces lie so closely in apposition to the vertebræ on each side, that a deceptive conclusion is suggested as to their being continuous in the middle line over that aspect of the axis, the dorsal one, which is attached to the matrix (as in Fig. 2).

I must confess that I find it, for the present, very difficult to put an interpretation upon this curious paired structure, and I must own also that it is possible that in the eyes of some it may appear to indicate a rudiment or remnant of a shoulder-girdle—an idea which would be somewhat fatal to the Marsipobranch theory of this organism. But if this piece on each side appertains to a pectoral arch, it can only, from its position, represent either a supra-clavicular or a post-temporal element, which would indicate a condition somewhat inconsistent with the otherwise very primitive structure of *Palæospondylus.* It seems to me quite possible that these two pieces may have been someway concerned in the support of the branchial apparatus.

The vertebral column is rarely well preserved; in fact, in the majority of specimens, it appears merely as a bituminous streak, with only faint indications of transverse segmentation. It is well shown in the specimen represented in Fig. 1, and in Fig. 3 I have represented, on a more magnified scale, the vertebral centra immediately behind the head in another example. These most anterior centra are rather shorter than broad, but farther back their length equals their breadth. Externally they are marked by several longitudinal grooves, of which one is median and ventral. Internally they are undoubtedly hollow, and are genuine ring-vertebræ, the hollow tubular interior being often opened into and shown by erosion, as is the case in the last vertebra, that on the left, represented in Fig. 3. The dorsal aspect of the vertebræ immediately behind the head is never shown, but so soon as the column gets twisted round on its side it may be seen that each centrum is surmounted by a somewhat square-shaped neural piece or arch. About the posterior two-thirds of the column these neural pieces become elongated into slender and very oblique spines, producing a fin-like elevation, which again falls away towards the point of the tail. A similar development of hæmal spines occurs at the same place on the ventral aspect of the axis, but here they are shorter, and the fin-like expansion consequently is not so deep. No interspinous elements and no fin-rays can be detected, yet *Palæospondylus* may be said to have a protocercal tail, and it is also interesting to observe that here the upper or dorsal fin-expansion is deeper than the lower or ventral one. Mr Woodward does not emphasise this in his figure, and he has also represented the neural and hæmal spines as much less oblique than they really are. He has also represented the vertebral centra all the way along as separated by intervals from each other, a condition which, according to my specimens, only occurs with the vertebræ immediately behind the head.

SUMMARY.

I have at present no further details regarding the structure of *Palæospondylus*, though there is every ground for hope that still better specimens may turn up in the locality in course of time. Meanwhile, what is already known may be summarised as follows:—

1. The cranium is of a simple structure, and no distinctly differentiated bones can be detected in its composition. It is seen only from the ventral surface, and consists of two parts—an anterior, comparable to the trabecular and palatal part of the lamprey's skull; and a posterior, also comparable to the parachordal part and auditory capsules. Evidence as to the condition of the nasal organ is deficient. The anterior margin shows several pointed processes or cirrhi. No trace of jaws have ever been detected in any of the numerous specimens which have been examined.

2. Immediately behind the head are two small, oblong, plate-like bodies, which in their natural position lie closely apposed to the commencement of the vertebral column, one on each side. Their morphological signification is quite obscure.

3. The notochordal sheath is calcified in the form of ring-shaped or hollow vertebral centra. These are furnished with neural arches, which, towards the caudal extremity, become produced into slender neural spines, while at the same place

on the opposite side are developed shorter hæmal ones. There are no ribs.

4. There are no paired limbs.

Is *Palæospondylus* possibly a larval form? If so, where is the adult? The other fossil Vertebrata of Achanarras are all common fishes of the Orcadian Old Red Sandstone area, and to none of them (not even *Coccosteus*) can parental relationship to this little creature be ascribed. Moreover, the high condition of differentiation of its vertebræ render the larval theory extremely improbable.

It seems, indeed, impossible to refer the organism to any existing vertebrate class, unless it be the Marsipobranchii or Cyclostomata, an alliance from which the calcification of the notochordal sheath in the form of ring vertebræ need not exclude it, though, to repeat my previous expression, it is a "rather startling idea." It is, however, better to avoid any appearance of dogmatism in this matter, and to wait in hopes that fresh material may throw still more light upon the structure of this strange relic of early vertebrate life.

EXPLANATION OF PLATE I.

Fig. 1. *Palæospondylus Gunni*, Traq.; magnified three diameters. From a specimen collected by Mr Donald Calder, of Thurso.

Fig. 2. Head of another specimen, not eroded; magnified five diameters.

Fig. 3. The first six vertebral centra of another specimen, seen from below; magnified eight diameters.

Figs. 4 and 5. Two heads as they usually occur, showing the effects of weathering or erosion.

IX. *On* Scorpæna dactyloptera, *Delaroche*,[1] *and its Occurrence in the British North Sea Area.* By WM. EAGLE CLARKE, Esq., F.L.S., M.B.O.U. [Plate II.]

(Read 15th March 1893.)

The first occurrence of this deep-sea fish on the coasts of Great Britain may be considered worthy of something more than a mere record of the details relating to that event, from the fact of this latest example having been obtained on the shores of the North Sea, whereby an extension of its geographical, and, perhaps, of its bathymetrical range is indicated.

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[1] I prefer to render this authority's name as he himself has given it. It is, however, quoted as "De la Roche" and "de Laroche" by authors.

This occurrence, too, directs attention to the circumstance, that this fish has no place in works treating on the ichthyology of the British Islands; and has suggested to the writer that it might be useful to give a short sketch of its history and natural history, so far as they are known to him, based upon the scattered information existing upon the subject. Advantage has also been taken of the opportunity of affording a faithful figure of the species, a desideratum, as Delaroche's plate—the only existing one—must be regarded as far from satisfactory.

This North Sea specimen was washed up on the sands at Coatham, on the Yorkshire coast, on the 2nd of February 1893. Here it was picked up by a fisherman, who, fortunately, took it to my friend Mr T. H. Nelson, a gentleman well known in the county for his great interest in natural history matters. Mr Nelson not only sent the specimen to me for examination, but has most kindly presented it to the collections in the Museum of Science and Art, Edinburgh. On examination, I found that the fish bore a considerable general resemblance to *Sebastes norwegicus*—a fact which I afterwards ascertained to be alluded to by several of its earliest historians. It differs, however, in several important and obvious characters, among others (1) in having the interorbital space narrow and concave; and (2) in having the dorsal spines longer than the dorsal rays.

The following is a description of this specimen, which is a young one, measuring 4·8 inches, or 122 millimetres, in length:—branchiostegals 7; dorsal spines 12, rays 13; anal spines 3, rays 5. The spines of the dorsal fin are strong and sharp, the third being the longest. The second spine of the anal fin is the longest. The rays of the pectoral fins are strong, and the inferior ones are free for about one-half their length—a peculiarity which has earned for this fish the specific name of *dactyloptera*. The interorbital space is very narrow, is concave, and has two lateral ridges on each side. The vertex is armed with prominent spines. There are five spines on the præoperculum, the second of which is the largest. There are also two spines of small size on the operculum. The maxilla reaches to beyond the centre of the eye. The specimen, when fresh, was of a beautiful golden-red colour, and did not exhibit the lateral bands or spots of brown or deep red which characterise the adult. Nor does the mandible project beyond the præmaxilla, though it is distinctly shown to do so in Delaroche's figure of the species. Delaroche, however, remarks that this is not a constant character.

According to other authorities, the adult of this beautiful fish is red, tinged with carmine, paler, almost white beneath, and banded or spotted with brown or dark red. The tongue is described as being free anteriorly. In addition, it is important to mention that this species is said not to possess a swim-bladder. The number of the pyloric cœca is 5, or, according to some authorities, 7.

The geographical distribution of *Scorpæna dactyloptera* is confined to the Mediterranean Sea; the north-east Atlantic Ocean, from the Cape Verd Islands to the coast of Norway; and now extends to the North Sea. Its bathymetrical distribution appears to range from 54 to 527 fathoms.

"La Scorpène dactyloptère" was made known to science by Dr Delaroche (1) from specimens obtained by him off Iviça, one of the Balearic Islands, during the winter of 1807-8. Here he tells us that his new fish is known by the name of the "Séran impériale," from its beautiful red colour; and he remarks upon its resemblance to the *Perca norwegica* of Fabricius. It is only to be found, according to this authority, in the great depths of the Mediterranean; and to be either very rare or little known at the ports where it is not the custom to fish at the depths frequented by this species. Delaroche was present at the capture of many specimens close to Iviça, from depths ranging from 160 to 180 fathoms; and in the vicinity of Barcelona, where the fish is called the "Panegal," it was obtained by him at 330 fathoms. The average size of the specimens was from two to three decimetres in length. As food he found it to be but little esteemed.

Further information regarding this species in the Mediterranean is afforded by several ichthyologists. Risso (2 and 3) says that it is very common off Nice, where it is found during the whole year amongst rocks at great depths; and is known by the name of "Cardouniero," from its spines. The female, he tells us, is full of eggs in summer; and that though the flesh of this fish is of little repute as food, it is made into soup. Cuvier and Valenciennes (8) describe it as a beautiful species, so much like *Sebastes norwegicus* in appearance, that it is necessary to place the two species side by side to distinguish them. These eminent authorities further say that this fish is not rare in any part of the Mediterranean, but only lives at great depths; and that it attains to a length of 18 inches, and then weighs four pounds or thereabouts. Guichenot (12) records it for the Algerian seas, and Sauvage (20), under the name of *Sebastes bibroni*, for those of Sicily. In the Adriatic, Faber (13) describes it as being general, but very scarce, and only quite accidentally met with at great depths; and he mentions off Trieste, the Island of Cherso, and the Dalmatian coast, as localities for it.

As an Atlantic species, *Scorpæna dactyloptera* has long been well known from Madeira, through the useful researches of Lowe (9 and 10); who records it as occurring off that island at depths varying from 250 to 400 fathoms. In the national collection, according to Dr Günther (14), in addition to numerous examples from Madeira, there is one from Lanzarote (Canary Islands), and a fine specimen from Lisbon. During the voyage of H.M.S. "Challenger," two minute specimens, respectively only 5 and 9 millimetres in length, were obtained as pelagic fishes off St Vincent, Cape de Verd Islands, on 26th April 1876. Dr Günther (4) remarks upon these specimens, that "as regards general shape, these young fishes do not differ from the adult, but the spines on the occiput and præoperculum are, comparatively, much larger and finely denticulated. The pectoral fin also is considerably longer, extending in the smaller specimens almost to the root of the caudal fin. Also the spines of this specimen are longer than the other." Concerning the occurrence of this and other deep-sea species as pelagic fishes, Dr Günther makes some observations of great interest. He remarks that for the greater part of their lives they inhabit the depths of the ocean, from 100 fathoms downwards; and proceeds to say that the "causes which make these fishes ascend to the surface is not known; but as some of them have been observed to make their appearance at the surface periodically, we may surmise that this change of habitat is in connection with their propagation. Indeed, most of them are found at the surface only during the early stages of their growth, and it would seem that their ova and fry require for development and growth the higher temperature and the light of the surface-water. These fishes connect the surface pelagic fauna with the deep-sea fauna." Vaillant (17), on the "Talisman," captured specimens at from 54 to 527 fathoms off the north-west coast of Africa.

The northernmost habitat of this fish, as yet ascertained, is off the Norwegian coast, whence it is recorded as occurring by both Collett (15) and Lilljeborg (16), and where it appears to be not uncommon in depths of from 100 to 300 fathoms.

Regarding *Scorpæna dactyloptera* as a British fish, there are but few records. It was described as new to the British fauna by Dr Günther (5) from several specimens obtained during a deep-sea trawling cruise off the south-west coast of Ireland, at a depth of 250 fathoms, during the first week of July 1889. The species, however, appears to be not uncommon off the west coast of Ireland, whence Holt (6) has recorded examples at depths ranging from 75 to 500 fathoms, in his valuable surveys of the Irish fishing grounds. Lastly, we have the Yorkshire specimen, obtained, as described, during the present year.[1]

From the information afforded by our little review of the history of this fish, its occurrence in the British North Sea area may be considered as very remarkable. The North Sea has been not inaptly described as "a great plain covered with shallow water." Its greatest depth, covering an area of any magnitude, within the British area is 50 fathoms, at some distance off the north-east coast of Scotland. South of this the sea shallows considerably, until 20 fathoms is reached off the north-east coast of England; while farther south it becomes shallower still, and 20 fathoms is only to be found quite locally. Here and there within this area few, remarkably few, depressions are to be found. A hole of over 100 fathoms is indicated on the chart of the North Sea as lying 13 miles off Troup Head, at the mouth of the Moray Firth. According to Olsen's "Piscatorial Atlas" there is a depression of 60 fathoms, some 30 miles east of Coquet Island; one of 50 fathoms, about 40 miles off Flamborough Head; another of 50 fathoms, about the same distance off the north-east coast of Lincolnshire; and lastly there is shown a sort of pit, with a maximum depth of 112 fathoms, situated some 50 miles east of the Forfarshire coast.

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[1] Since this was printed, I have been informed by Mr E. W. L. Holt that a specimen has been recently captured in the Humber estuary.

So far as our present knowledge of the habitat suited to the existence of *Scorpæna dactyloptera* allows us to venture an opinion, the two abysses—for abysses they are in these shallow waters—in our North Sea area afford the only congenial haunts for this fish. It may, eventually, be found to inhabit shallower water; but the circumstance that the species has long been known to naturalists as a deep-sea form only, would seem to be weighty argument against the likelihood of such proving to be the case. In this particular connection it may be well to remark that Mr Holt, who speaks with authority on this species, has said that "our information is not as yet sufficient to show any marked difference in the habitats of the old and young forms." It would, I think, seem not improbable, from what we know concerning the life-history of this fish in its extreme youth, that the young may be eventually found to inhabit shallower waters than the adults.

The facts that this English specimen was picked up in a perfectly fresh and uninjured condition, and its being a young one, afford important evidence in favour of its British origin, in the true sense of that term. This belief necessarily implies that the species is established somewhere near our shores. When we remember that this fish in its early life is pelagic in its habits—a condition peculiarly favourable to the spread of the species—it is not impossible that a colony may have—somewhat recently, perhaps—been formed by offspring of Scandinavian origin, for we know that it is numerous off the Norwegian coast. This colony may, possibly, be established in the accustomed depths inhabited by this species; or, it may be, that our British representatives are dwelling in somewhat shallower waters than those in which *Scorpæna dactyloptera* has been, as yet, ascertained to flourish.

SYNONYMY AND LITERATURE.

Scorpæna dactyloptera, *Delaroche.*

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5. Günther, A., Deep-Sea Trawling off the S.W. Coast of Ireland—Fishes, *Ann. and Mag. Nat. Hist.* (6), vol. iv., p. 417 (1889).
6. Holt, E. W. L., Survey of Fishing Grounds, West Coast of Ireland, *Sci. Proc. Roy. Dublin Soc.*, vol. vii., pp. 121, 219, 248, 261, 273, 429 (1891-92).
7. Nelson, T. H., and Clarke, W. Eagle, Scorpæna dactyloptera on the Yorkshire Coast, *Naturalist*, 1893, p. 81.

Sebastes imperialis, *Cuv.* and *Val.*

8. Cuvier, G., and Valenciennes, A., *Hist. Nat. des Poissons*, vol. iv., pp. 336-340 (1829).
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12. Guichenot, A., *L'Exploration Scientifique de l'Algérie:* Poissons, p. 42 (1850).
13. Faber, G. L., *The Fisheries of the Adriatic, and the Fish thereof*, pp. 75, 193, 237 (1883).

Sebastes dactylopterus (*Delaroche*).

14. Günther, A., *Cat. Acanth. Fishes*, vol. ii., pp. 99, 519 (1860).
15. Collett, R., *Norges Fiske*, p. 19 (1875).
16. Lilljeborg, W., *Sveriges och Norges Fiskar*, p. 107 (1881-).
17. Vaillant, L., *Exped. Scientifique du Travailleur et du Talisman pendant les années* 1880-1883. Poissons, p. 368 (1888).

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18. Gill, T., On an unnamed generic type allied to Sebastes (Sebastoplus, Gill), *Proc. Acad. Nat. Sci. Philadelphia*, 1863, pp. 207-209.
19. Meek, S. E., and Newland, R., Review of the American Species of the Genus Scorpæna, *Proc. Acad. Nat. Sci. Philadelphia*, 1885, p. 394.

Sebastes (Sebastichthys) bibroni, *Sauvage.*

20. Sauvage, H. E., Description de Poissons Nouveaux ou imparfaitment connus de la collection du Muséum d'Histoire Naturelle, *Nouv. Arch. Mus. Hist. Nat.* (2), vol. i., p. 116, pl. i., fig. 3 (1878).
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X. *On the Occurrence of* Arthrostigma gracile, *Dawson, in the Lower Old Red Sandstone of Perthshire.* By ROBERT KIDSTON, Esq., F.R.S.E., F.G.S. [Plate III.]

(Read 15th March 1893.)

In a paper published in 1877 by Messrs R. L. Jack and R. Etheridge, jun., is given an account of the "Discovery of Plants in the Lower Old Red Sandstone of the Neighbourhood of Callander,"[1] by Mr A. Macconochie. This communication is introduced by an excellent Bibliography of the Scottish Old Red Sandstone Flora up to the date of its publication, which is followed by a description of certain specimens from the Lower Old Red Sandstone of Perthshire, concluding with remarks on the Geology of the Old Red Rocks in the district specially dealt with.

To a few of the specimens described in this paper, as *Psilophyton* sp., I wish to call further attention.

Of these fossils two reduced figures were given—Fig. 1 from quarry, near Braeandam House, Callander, and Fig. 2 from south-west corner of Muir Plantation, near Braeandam House.

Messrs Jack and Etheridge state, in regard to these specimens, that they were convinced of their great resemblance to and affinity with Dawson's genera *Psilophyton* (especially *P. princeps*) and *Arthrostigma*, "our own conclusion being that the closest affinity was with the latter genus."[2]

For the purpose of confirming or correcting their views, the better examples were submitted to Mr R. Etheridge, F.R.S., and Mr W. Carruthers, F.R.S., and the latter furnished the following note on the specimens:—

"They have a true Lepidodendroid structure. The axis consisted of a slender column of vascular tissue; the soft cellular tissue left an undefined carbonaceous stain, except where the opening for the passage out of the vascular bundles existed, the scars of which are well seen from the inside.

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[1] Quart. Jour. Geol. Soc., 1877, p. 213.

[2] *Loc. cit.*, p. 218.

These are like *Cyclostigma* markings; but in this specimen they are certainly the markings on the inner surface of the false bark of these plants. The spines are, I believe, the persistent bases of leaves, not the leaves themselves, though that is possible. But I see, I think, indications of their being bases from which the leaves have disappeared. The leaf is not clean-cut on the upper margin, but has something like a cicatrix scar."

Mr Carruthers concludes his remarks by saying: "As to their name, it is probably the larger stem of a plant like Dawson's *Psilophyton princeps*, with which it agrees in structure, etc. No doubt his *Arthrostigma* and *Cyclostigma* are the same things; but we yet want light as to the true nature of these Devonian Lycopods."[1]

The authors of the paper then state: "The preceding facts comprise all the information we at present possess bearing on these interesting fragments. Beyond the probable dichotomous method of branching, we are unacquainted with any of the broader characters; neither do we know anything of the fructification.

"The plentiful manner in which the matrix is traversed, gives rise to the hope that the discovery of more perfect specimens is only a matter of time and careful search. Under these circumstances, we content ourselves with appending a short provisional description, under the name of *Psilophyton* (?) sp., in accordance with the suggestion of Mr Carruthers, as given above."

PSILOPHYTON (?) sp.

"Stems branching dichotomously, and covered with spirally oblique lines of short, rigid, pointed and slightly curved thorn- or spine-like projections, the persistent bases of the leaves, or perhaps the leaves themselves. Axis composed of a slender column of vascular tissue, surrounded by a cylinder of cellular tissue."

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[1] This description refers to characters which none of the Perthshire specimens which I have seen shows.

For the privilege of examining the specimens which formed the subject of these remarks by Messrs Jack, Etheridge, and Carruthers, just quoted, I am indebted to Sir Archibald Geikie. The conclusions to which I have come, after a careful examination of the fossils, is, that the original suggestion of Messrs Jack and Etheridge, that the affinity of the fossils was with *Arthrostigma*, is the correct view of their relationship; and if Sir William Dawson has been correct in referring to *Arthrostigma* the curious little fructification which he associates with his *Arthrostigma gracile*, the plants are very distinct from *Psilophyton*, and I do not see any reason for rejecting Dawson's views in regard to the fructification of his *Arthrostigma gracile*. The fossils probably belong to the *Lycopodiaceæ*, but I am not aware on what grounds Mr Carruthers states that they have a "true Lepidodendroid structure," and taking into consideration the differences in the fructification of *Psilophyton* and *Arthrostigma*, how they can possibly be regarded as "the same thing."

It is possible that the plants placed by Dawson in *Cyclostigma* may be fragments of his *Arthrostigma*, but Haughton's genus *Cyclostigma* is a very different plant, and perhaps not generally distinct from *Bothrodendron*.

But before further discussing the identity of the Braeandam specimens, it may be well to consider the generic characters of Dawson's genus *Arthrostigma*.

ARTHROSTIGMA, Dawson, 1871.

Geological Survey of Canada—Fossil Plants of Devonian and Upper Silurian Formations of Canada, p. 41.

"Stems elongated, cylindrical, bifurcating, and giving off lateral branches; irregularly furrowed or ribbed longitudinally, with circular leaf-scars arranged in whorls, and bearing linear rigid leaves with circular bases. Structure apparently cellular, with a slender vascular axis; fructification probably in cylindrical strobiles."

In the second part of the "Fossil Plants of the Erian (Devonian) and Upper Silurian Formations of Canada," published in 1882, Dawson supplements the description of the fruit of *Arthrostigma* from specimens found at Campbellton. He says: "At Campbellton also the cones are better preserved, and I have figured one of them on plate xxiv. fig. 22. They have apparently been cylindrical, but there seems reason to doubt whether they were strobiles bearing very thick and somewhat open scales, or spikes of sack-like spore-cases. The Campbellton specimens certainly favour the latter conclusion, and if this is correct, the fructification of this plant was of a very peculiar character, and in some respects more nearly allied to that of *Psilophyton* than to that of true Lycopods."

"From these additional specimens, *Arthrostigma gracile* would seem to have been a small shrubby plant, with stems not exceeding an inch in diameter, and sparsely covered with conical spine-like leaves, which left, when detached, round scars like those of *Cyclostigma*. The branches, which were developed by bifurcation, were densely crowded with acicular leaves nearly at right angles to them, and were terminated by cylindrical spikes of fructification."[1]

The genus *Arthrostigma* has been compared by some with Haughton's *Cyclostigma*,[2] and they appear to agree in both having circular or oval leaf-scars, but with this single point of resemblance, any further comparison ceases. Instead of the abortive thorn-like leaves of *Arthrostigma*, *Cyclostigma* has long well-developed grass-like foliage, and the fruit is, I believe, the cones with long linear bracts, described by Schimper as *Lepidostrobus Bailyanus*.[3] *Cyclostigma* further attained to arborescent dimensions. In *Arthrostigma* the leaves are rudimentary and spine-like, and the fruit consists of small cone-like structures, most probably consisting of a spike of sack-like spore-cases. Dawson believes the cones were probably cylindrical, but if one may judge from his figures, the sporangia appear to be ranged in two opposite rows. But whatever may have been the minute structure of the cone, *Arthrostigma* is essentially distinct from *Cyclostigma*

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[1] *Loc. cit.*, p. 104.

[2] Read Roy. Dublin Soc., May 27, 1859. Jour. Roy. Dublin Soc., vol. ii.

[3] Traité d. paléont. végét., vol. ii., p. 71, pl. lxi., figs. 9, 9*a*, 9*b*.

Haughton, on the one hand, and from *Psilophyton* on the other—where in the latter genus the fructification consists of "naked oval spore-cases, borne usually in pairs on slender curved pedicels." The affinities of *Arthrostigma* appear, however, to be closer to *Psilophyton* than any other known genus. If the fruit of *Arthrostigma* consisted of a spike of spore-cases arranged in two rows, which I am inclined to think is the correct explanation of its structure, we may then compare it to the fructification of *Psilophyton*—where the naked sporangia were borne generally in pairs at the ends of the branches, whereas in *Arthrostigma* the sporangia (apparently without accompanying bracts) were arranged in two rows, one row on each side of a common axis.

No remains of fructification were found with the Perthshire specimens, but in connection with this subject attention may be drawn to the figure of a "Fern (?) of Lower Old Red Sandstone, Orkney," given in the "Testimony of the Rocks" (in 1857 edition), p. 25, fig. 13, and described at p. 431 as follows:—

"In the flagstones of Orkney there occurs, though very rarely, a minute vegetable organism, which I have elsewhere described as having much the appearance of one of our smaller ferns, such as the maidenhair-spleenwort, or dwarf moonwort. It consists of a minute stem, partially covered by what seems to be a small sheath or hollow bract,[1] and bifurcates into two fronds or pinnæ, fringed by from ten to twelve leaflets, that nearly impinge on each other, and somewhat resemble in their mode of arrangement the leaflets of one of our commonest Aspleniums—*Asplenium trichomanes*. One of our highest authorities, however, in such matters, (the late) Professor Balfour of Edinburgh, questions whether this organism be in reality a fern, and describes it, from the specimen on the table, in the Palæontological chapter of his admirable class-book, simply as 'a remarkable pinnate frond.'"

The specimen referred to above was figured in an earlier work by Hugh Miller, the "Footprints of the Creator" (3rd edition), 1850, p. 193, fig. 56. The description is not so fully given here, and what is said refers more to its condition of preservation.

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[1] This supposed bract appears to be only a separated portion of the stem.

"An Orkney specimen, lately sent me by Mr Wm. Watt, from a quarry at Skaill, has much the appearance of one of the smaller ferns, such as the moorworts, sea spleenworts, or maidenhairs."

"It exists as an impression in diluted black, on a ground of dark grey, and has so little sharpness of outline, that, like minute figures in oil paintings, it seems more distinct when viewed at arm's length than when microscopically examined, but enough remains to show that it must have been a terrestrial, not a marine plant. The accompanying print (fig. 56) may be regarded as no unfaithful representation of this unique fossil in its state of imperfect keeping."

This interesting specimen is now preserved in the Palæontological Collection of the Museum of Science and Art, Edinburgh. As pointed out by Hugh Miller, it is very imperfectly preserved, but seems to me to very much resemble the fruit of *Arthrostigma*—it is evidently not a fern—but its true nature cannot, on account of its imperfect preservation, be satisfactorily determined. *Arthrostigma* has not, however, as far as I am aware, been yet met with in Orkney, but the Old Red Sandstone plants have been so little collected systematically, that one can scarcely say what species do or do not occur at most of the localities from which plant remains have been secured.

Having now so fully discussed the broader questions referring to the genus *Arthrostigma,* we may turn our attention to the Perthshire examples which are the immediate cause of this communication.

Of these there are five examples before me. They consist of fragments of stems, varying in length, and of a width from rather under ¾ of an inch to 1¼ inch. They are much compressed, and show projecting from their margins the spine-like rudimentary leaves. These are generally slightly falcate or hook-shaped, though occasionally straight. When the leaves are removed from the stems, they leave behind a circular scar; this, however, is seldom well shown on our specimens, though in a few instances it is exhibited. I do not think that these spine-like structures are the *bases* of leaves, as has been suggested, but are the leaves themselves, though developed in a very rudimentary form, as in *Psilophyton*. Though the leaves now appear as flattened thorn-like outgrowths, that they were originally circular is proved by the circular scar they leave when removed from the stems. When the stems are denuded of their spine-like leaves, the scar they leave gives the fossil very much the appearance of a *Stigmaria*.

The surface of the stems are irregularly striated longitudinally, and bear tubercle-like prominences—the points to which the leaves have been attached. These prominences in their present condition are, probably, more elevated than they were in life, by the shrinkage of the bark. Owing to compression of the fossils, the disposition of the leaves is not very clearly shown on most of the specimens, but on the best preserved they are seen to be arranged in spirals.

The characters possessed by these fossils clearly show their position to be in Dawson's genus *Arthrostigma*.

It is true that Dawson mentions that the leaf-scars are arranged in whorls, and on the great majority of the specimens it is impossible to determine satisfactorily their arrangement, and even on Dawson's figures of *Arthrostigma gracile* this point is obscurely illustrated,—on some of his examples the leaves do appear to be arranged in whorls, but on others they seem to be spirally disposed; so this point, as to whether the leaves were in whorls or placed in spirals, cannot at present be insisted on as offering any distinguishing character. Then again, the majority of the spine-like leaves on Dawson's figures appear to be straight, while a few are falcate; on the Perthshire specimens, the majority are falcate, while a few are straight.

There is, therefore, no definite point of difference between the Canadian and Scottish examples in any of these characters. Dawson further says, that "*Arthrostigma gracile* would seem to have been a small shrubby plant, with stems not exceeding an inch in diameter."

Some of the Perthshire stems are certainly a little broader than an inch, but on that difference alone one is quite unwarranted in founding a new species. I am, therefore, led to conclude that the Perthshire specimens must be identified as *Arthrostigma gracile*, Dawson, and though they seem to be somewhat larger than the original specimens of the species, they do not appear to differ in any important character, as far as can be observed (from the material at our disposal), from the Canadian species.

ARTHROSTIGMA GRACILE, Dawson.

[Plate III.]

Arthrostigma gracile, Dawson, Geol. Survey of Canada—The Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 41, pl. xiii.; part ii., 1882, p. 104, pl. xxiv., fig. 22.

Description of specimens here figured:—

FIG. 1.—This is the specimen given by Messrs Jack and Etheridge in their paper on p. 217, fig. 1. My figure is natural size.

The fossil shows portion of a stem about 6½ inches long, and rather under an inch broad at its thickest part. The arrangement of the leaves is not clearly shown, but the stem exhibits the irregular longitudinal striations and the spine-like leaves projecting past the margin of the stem. These, when perfect, are here seen to be fulcate.

In the description of the reduced figure given by the authors already mentioned, they say, "portion of a simple stem, with the cellular tissue destroyed at one end, leaving the vascular axis." There is evidently some mistake in this description, for at no part does the specimen show any trace of the vascular axis, unless it be found in indications of a ribbon-like band running up the centre of the stem.[1]

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[1] On another specimen from the quarry west of Braeandam House (Reg. No. M/482^{b}), among other fragments of stems is one three inches long and rather over an inch wide. It narrows slightly towards one end, and up its centre runs a clearly defined carbonaceous ribbon-like band, about one-tenth inch thick. This may be the remains of the vascular system shadowed through the much compressed stem.

Fig. 1*a* shows one of the leaves, which is very distinctly defined on the original; slightly enlarged.

FIG. 2.—This is the other specimen which was figured by Messrs Jack and Etheridge, and is here given natural size.

It shows a bifurcating branch. The specimen is a little indistinct at the base, and I am not sure that the lower part of the specimen is broken over—rather, I think, that it bends upwards again. At *a* a much smaller branch—perhaps a root —is given off. The leaves are not well shown, but the specimen is interesting as showing the bifurcation and the giving off of the small root-like branch *a*.

FIG. 3, also natural size, shows portion of a stem denuded of its leaves, where the stigmaria-like appearance has been assumed. This specimen further illustrates the spiral arrangement of the leaves.

FIG. 4 shows an enlarged leaf from another specimen.

All these specimens were collected by Mr A. Macconochie, one of the staff of the Geological Survey of Scotland.

Localities.—Fig. 1 (Reg. No. $^{M}/488^{b}$), Fig. 3 (Reg. No. $^{M}/492^{b}$), and Fig. 4 (Reg. No. $^{M}/484^{b}$) from quarry west of Braeandam House, 2½ miles south by east of Callander.

Fig. 2 (Reg. No. $^{M}/499^{b}$), on roadside, south-west of Muir Plantation, 3½ miles south by east of Callander.

Horizon.—Lower Old Red Sandstone. In greenish-grey flags and thin-bedded sandstones—in horizon "C" of section given by Messrs Jack and Etheridge (*loc. cit.*, p. 220).

Before finally leaving this subject, attention might be called to certain fossils figured and described by Stur under the name of *Lessonia bohemica* in his memoir "Die Silur- Flora der Etage H-h, in Böhmen,"[1] which seem to be very closely related to *Arthrostigma gracile*, if not identical with it; but one cannot speak with any certainty from an examination of his figures and descriptions, as Stur's examples do not seem to have been well preserved. Some of the other plants he figures from this horizon also seem to be identical with some of our

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[1] Sitzb. d. k. Akad. Wissensch., Abth. i., Band lxxxiv., Juli-heft, Jahrgang 1881, p. 330.

Old Red Sandstone species. One would therefore be inclined to think that the rocks which contained these fossils should rather be referred to the Lower Old Red Sandstone than to the Silurian formation.

Stur places his *Lessonia* in the *Laminariæ*. I altogether doubt the algal affinity of his fossils, and if my suspicions are correct as to the nature of his specimens, they must be referred to the *Lycopodiaceæ*.

In any case, in absence of fructification, it is unsafe to refer Stur's fossils to any existing order of Algæ.

EXPLANATION OF PLATE.

Figs. 1-4. *Arthrostigma gracile*, Dawson; from the Lower Old Red Sandstone of Perthshire.

XI. *Notes on the Devonian Fishes of Campbelltown and Scaumenac Bay in Canada.* Part I. By R. H. TRAQUAIR, Esq., M.D., LL.D., F.R.S., F.G.S.

(Read 15th March 1893.)

Mr Damon, of Weymouth, having recently received a third consignment of fossil fishes and fish remains from the Devonian rocks of Canada, an interesting selection has been made for the Edinburgh Museum, and I am thus enabled to contribute some additional notes regarding the palæozoic ichthyology of this region. The specimens were, as before, collected by Mr Jex.

FISHES FROM THE LOWER DEVONIAN OF CAMPBELLTOWN.

Protodus Jexi, A. S. Woodward.

Geol. Mag., dec. iii., vol. ix., 1892, pp. 1, 2, pl. i., figs. 1, 1*a*.

A great many specimens of this tooth have been last summer collected by Mr Jex. That it is a selachian tooth is proved beyond doubt, not merely by its shape, but by its occasionally occurring in transverse bands, three or four being in apposition in a row back to front.

Doliodus problematicus (A. S. Woodward).

Diplodus problematicus, A. S. Woodward, *op. cit.*, p. 2, pl. i., fig. 2.

Only a single specimen of this curious tooth was at Mr Smith Woodward's disposal, and that, too, only exhibiting the crown and denticles, being destitute of the root. The cusps certainly resemble those of *Diplodus* in form and arrangement, but the peculiar form of the base, which is well shown in many of the specimens now before me, is very different, and necessitates the institution of a new genus, which, on account of the deceptive appearance of the first described example, I propose to name *Doliodus*.[1]

Instead of the thick, solid base of *Diplodus*, we have here a broad thin plate, convex anteriorly and above, concave posteriorly and below, to the upper margin of which the crown is attached. The type specimen has only one intermediate cusp, but their number may vary from one to three or even four.

In connection with the generic separation of this form of tooth from *Diplodus*, Ag., it is interesting to observe that, although during his last visit to Canada Mr Jex obtained a large number of these teeth, not one example of a Pleuracanth spine has occurred in the same beds. I therefore doubt its being even referable to the family Pleuracanthidæ.

? Cheiracanthus costellatus, sp. nov.

Several detached spines and one fish wanting the head constitute the remains of this interesting species, which are contained in the present collection.

The fish measures 4 inches in length, but it is so distorted and shortened up that its real dimensions and contour cannot be determined. Six spines are shown, which I interpret as two pectoral, two ventral, one dorsal, and one anal. The spines are large and rather slender, the pectoral measuring 1⅜ inch in length, and ⅛ inch in breadth about the middle, the dorsal 2⅛ inches. The others are imperfect, but all are remarkably straight save the pectoral, which is gently curved. The exposed surface of the spines is marked by prominent longitudinal ridges and furrows, there being four to six on each side, while the median one along the anterior aspect of the spine is broader than the others. There are two clavicular elements near the pectoral spines, which resemble in form rather more those of *Cheiracanthus* than of *Acanthodes*. The scales are marked on their exposed surfaces with extremely fine striæ, which are only visible under a strong lens, and pass longitudinally across the scale in a direction parallel to the diagonal, connecting the anterior and posterior angles.

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[1] Gr. Δόλιος, a deceiver.

On first seeing the spines, I thought of Whiteaves's *Homacanthus gracilis* from the same beds; but they are more slender, and have less of a "conical" shape than the spine figured by that author; besides which there are no signs of posterior denticles. It is unfortunate that the fish is so distorted that the relative position of the spines, and especially of the dorsal, with regard to the anal is obscured, so that its reference to *Cheiracanthus* must of course be considered as merely provisional; indeed, against this reference may be mentioned the fact that, in their strongly fluted character, the spines rather deviate from those of the well-known Scottish species *Ch. Murchisoni* and *Ch. latus*.

Cephalaspis Campbelltownensis, Whiteaves.

Whiteaves, Canadian Nat., N.S., vol. x., p. 98; and Trans. Roy. Soc. Canada, vol. vi., sec. iv., p. 92, pl. x., fig.

In a former paper[1] I recognised two distinct species of *Cephalaspis* from the Campbelltown beds, one having the cephalic shield rounded in front, the other in which it assumed a pointed form, like the snout of a skate. Misled by Mr Whiteaves's figure, I referred the former to his

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[1] Geol. Mag. (3), vol. vii., 1890, pp. 15-22.

C. Campbelltownensis; to the latter I attached the name of *C. Whiteavesi*.

Mr Smith Woodward, having had subsequently the privilege of inspecting the original type of *C. Campbelltownensis*, found that it actually possessed the pointed rostrum characteristic of my *C. Whiteavesi*, which rostrum had been omitted in the drawing published by Mr Whiteaves.[1] Consequently my species had to go, though it was clear that there was something still to be determined regarding the species of *Cephalaspis* occurring at Campbelltown.

The mystery is quite cleared up by the specimens in the present collection; there *are* two species, but the new one is that with the *rounded* snout, which I shall describe under the name of

Cephalaspis Jexi, sp. nov.

Cephalic shield rounded in front, cornua incurved, comparatively short and stout; the orbits relatively smaller than in *C. Campbelltownensis*, situated nearly midway between the anterior and posterior extremities of the shield. The external ornament of the shield consists of minute closely-set tubercles, often tending to be ranged in concentric lines, which are parallel to the borders of the tesserae. On the cornua the tubercles are not so close, showing intervals which are finely longitudinally striated. The inner margins of the cornua are distinctly denticulated.

In *C. Campbelltownensis*, on the other hand, the front of the shield is produced into a pointed rostrum, the cornua are relatively longer, the orbits relatively larger than in the preceding species. The ornamentation of the cornua and the denticulation of their inner margins is more delicate, the former consisting of minute pits and reticulating furrows, the interspaces between which appear as minute flattened tubercles.

Both of these species seem to be common at Campbelltown, but perfect shields of *C. Jexi* are rare, being mostly broken on one side, or else distorted by pressure; whereas those of *C. Campbelltownensis* more commonly retain their contour complete. As the name *Whiteavesi*, having dropped, cannot, according to the rules of nomenclature, be again applied to a different species of *Cephalaspis*, I have pleasure in dedicating this new one to Mr Jex.

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[1] A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. ii., p. 191.

Phlyctænaspis Acadica, Whiteaves.

Coccosteus Acadicus, Whiteaves, Trans. Roy. Soc. Canada, vol. vi., sect. iv., p. 93, pl. ix. and woodcut.

Phlyctænaspis Acadica, Traquair, Geol. Mag., dec. iii., vol. vii., pp. 20 and 60, pl. iii., figs. 1, 2.

Phlyctænaspis Acadica, A. S. Woodward, Cat. Foss. Fishes British Museum, pt. ii., p. 259; also in Geol. Mag., dec. iii., vol. viii., 1891, p. 5.

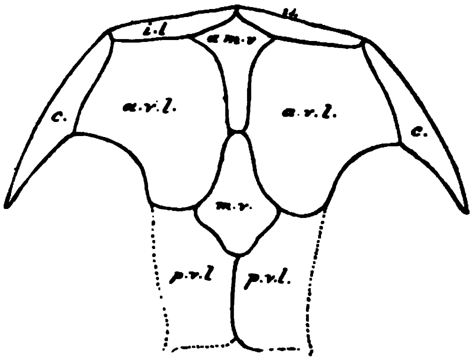
This collection is rich in remains of *Phlyctænaspis Acadica*, among which are some specimens which throw fresh light upon the structure of this interesting and still imperfectly known genus.

One of them shows a large portion of the ventral shield with nearly all its plates *in situ*, and from it, along with detached plates, I have drawn the accompanying restoration, which clears up, I think, certain important points recently discussed by Mr Smith Woodward.

This specimen shows the left anterior ventro-lateral plate and part of the right one, also the median ventral plate and the greater part of the posterior ventro-lateral plate of the left side, and finally the left lateral spine or cornu in connection with the corresponding anterior ventro-lateral.

The anterior median ventral is not here exhibited, but as it occurs detached in another specimen, I have, in the figure, inserted it in its place. The median ventral is, however, well shown in position, and detached examples of it occur showing both outer and inner aspects. Both of these median plates closely resemble the corresponding plates in *Coccosteus.*

So does the anterior ventro-lateral (*a.v.l.*), which is quite correctly identified by Whiteaves (*op. cit.*, pl. ix., fig. 3). Now attached to the antero-external margin of this plate is seen the spine-like body recently described by Mr Smith Woodward. This spine occurs not only in the specimen on which the above restored sketch is founded, but in the collection now before me is found both absolutely detached, and also in articulation with otherwise isolated examples of the anterior ventro-lateral plate.



Phlyctænaspis Acadica, Whiteaves; restoration of ventral carapace. *a.v.l.*, anterior ventro-lateral plates; *p.v.l.*, posterior ventro-lateral, not defined in the outer margin in the fossil; *a.m.v.*, anterior median ventral; *m.v.*, median ventral; *i.l.*, interlateral; *c.*, cornu or lateral spine.

Mr Woodward mentions these spines as "each apposed to a lateral plate of the trunk": it is now shown to *which* lateral plate, as well as to which part of the dermal armour of *Coccosteus*, they correspond.

It will be seen that the spine (*c.*) touches with its proximal extremity a narrow portion of bone (*i.l.*), which is articulated with the anterior margin of the anterior ventro-lateral plate (*a.v.l.*). On turning to my previous restoration of the ventral cuirass of *Coccosteus decipiens*, Ag.,[1] it will at once be seen that this portion of bone corresponds exactly to the anterior-inferior part of the interlateral plate (*i.l.*), which occupies the same position with regard to the anterior ventro-lateral, and meets its fellow of the opposite side in front of the anterior median ventral (*a.m.v.*), while the spine, in like manner, corresponds to the short process which passes backwards separating the anterior ventro-lateral below from the antero-lateral above. This process, short in *C. decipiens*, is more largely developed in *C. minor*, H. Miller, in which species I have stated that it has a "very spine-like appearance," though, owing to the proportionally greater extent of the margins of the antero-lateral and anterior ventro-lateral plates with which it articulates, it forms no more of an independent projection than in the former.[1] But as in *Phlyctænaspis* this spine seems divided by a very distinct suture from the interlateral plate, I have carefully examined the suite of specimens, both of *Coccosteus decipiens* and *C. minor*, in the Edinburgh Museum, with the result that I have convinced myself that the process in question is here also a distinct element, to which the name of "lateral spine" may appropriately be given. In both genera it is immovably fixed; in one example of *Phlyctænaspis* it seems indeed anchylosed to the interlateral plate.

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[1] Ann. and Mag. Nat. Hist. (6), vol. v., 1890, pl. x., fig. 3.

Consideration of this element of the cuirass of the Coccosteidæ calls up, of course, the question of *Acanthaspis*, Newberry. Mr Smith Woodward[2] remarks that the spines of *Phlyctænaspis* "are indeed precisely similar in external form and appearance to those of *Acanthaspis;* and so far as can be judged from known specimens they only differ from the last-mentioned spines in the circumstance that the supporting plate is destitute of the extended oblique pedicle observed both in the type specimens from the Corniferous Limestone of Ohio, and in the shield assigned to the same genus from Spitzbergen. It thus remains to discover more associated examples of the plates and spines from Ohio, to determine whether they actually pertain to Ostracoderms, as suspected, or whether they represent part of the armour characteristic of Arthrodira; for the fixed spinous appendage is now proved to occur in both of these widely-separated groups."

It will be remembered that Mr Woodward, in a previous paper,[3] was inclined to consider *Acanthaspis* as being "most nearly related to the Asterolepidæ, and its spine-like processes to be the homologue of the well-known pectoral-paddles of the latter." But a comparison of Newberry's figures with the sketch of the ventral cuirass of *Phlyctænaspis* given above will remove all doubt as to the Coccostean character of the remains from the Corniferous Limestone of Ohio; figures 1, 2, 3, and 4 on plate lv. of Prof. Newberry's work,[1] representing obviously the lateral spine in conjunction with the anterior ventro-lateral plate of a creature allied to the Canadian genus, though the supporting plate is remarkably short from before backwards. The same view must, I think, be adopted for Mr Woodward's *Acanthaspis decipiens* from Spitzbergen, so that I cannot consider the occurrence of a fixed spinous appendage to be as yet proved in any genus specially allied to the Asterolepidæ. Whether this fixed spine is in any way homologous to the articulated appendage of Asterolepidæ, or to the pectoral limb of vertebrates in general, I need not at present discuss.

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[1] R. H. Traquair, Geol. Mag., dec. iii., vol. vi., pl. i., fig. 3.

[2] *Op. cit.*, p. 481.

[3] Devonian Fish-Fauna of Spitzbergen—Ann. and Mag. Nat. Hist. (6), vol. viii., pp. 1-15.

Associated with other plates of *Phlyctænaspis Acadica*, are several fragments of dentigerous bones, showing small, smooth-pointed conical teeth in one row.

XII. *Notes on the Devonian Fishes of Campbelltown and Scaumenac Bay in Canada.* Part II. By R. H. Traquair, Esq., M.D., LL.D., F.R.S., F.G.S.

(Read 19th April 1893.)

FISHES FROM THE UPPER DEVONIAN OF DALHOUSIE, SCAUMENAC BAY.

CTENODONTIDÆ.

Scaumenacia curta (Whiteaves).

Phaneropleuron curtum, Whiteaves, Canad. Nat., N.S., vol. x., p. 21; also in Trans. Roy. Soc. Canada, vol. iv., sect. iv., p. 108, fig. 2, and vol. vi., sect. iv., p. 91, pl. v., fig. 3; A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. ii., p. 248.

Mr Whiteaves, in his description of this species, mentions that "in one specimen there are indications of what looks like a short break or separation between the anterior and posterior portions of the dorsal (or between the two dorsals if there were two, which is scarcely probable), but this break may be owing to an accidental and abnormal fracture of the fin-rays at this point, for in other specimens the two portions appear to be continuous." This break is, however, represented in all his figures, including the restored sketch given in his second paper in the *Transactions of the Royal Society of Canada*.

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[1] Geol. Survey of Ohio, Palæontology, vol. ii.

But on looking carefully through the whole of the extensive series of this species collected by Mr Jex last summer, and also on re-examining the specimens already in the Museum, I find that there is no doubt whatever, that in all of them the dorsal fin is in two distinct portions, which are separated from each other by a very perceptible interval.

The anterior dorsal commences far forwards; it is low and fringing in character, and the length of its base is contained two and a half times in that of the posterior dorsal, the interval between the two fins being equal to one-third of the length of the base of the anterior. The base of the second dorsal extends to a point a little beyond the commencement of the lower lobe of the caudal, but as its rays are long, and the posterior ones directed nearly horizontally backwards, the fin seems to extend near to the tip of the tail. It does not, however, form a continuous dorso-caudal as in *Phaneropleuron*, as hitherto described, or in *Ceratodus* or *Uronemus*, and Mr Whiteaves is certainly in error in making it do so in his restored figure already referred to. As regards the caudal fin, it is in reality *heterocercal*, the upper lobe being represented only by very short rays towards the tip of the body prolongation, while on the ventral aspect the lower lobe is of the triangular form characteristic of *Dipterus*. Indeed, the resemblance of the fins to those of *D. macropterus*, Traq., from John o' Groats, is very remarkable, the most striking difference being the more extended base and fringing form of the anterior dorsal in the species under consideration. *Dipterus Valenciennesii*, *D. macropterus*, and *Scaumenacia curta* form then a complete and most interesting series as regards the configuration of their dorsal fins; in the first both dorsals are short based, in the second the posterior dorsal has a base of considerable length, in the third the anterior dorsal is long based, while the base of the posterior one is still longer than in the second.

The question here arises, What is the condition of the dorsal fin-arrangement in the typical *Phaneropleuron Andersoni*, Huxley? for on that depends the validity of the new genus which I propose, provisionally at least, to institute for the reception of Whiteaves's *Ph. curtum*. In the Dura Den fish the dorsal fin was originally described by Huxley, and afterwards by myself, as continuous anteriorly, and if that description holds good *Ph. Andersoni* occupies the fourth place[1] in the series of dorsal fin differentiations, and the Canadian species is also generically distinct. The specimens of *Ph. Andersoni* in Edinburgh, or even in the splendid collection of Dura Den fishes at St Andrews, are not sufficiently perfect in the region to afford a decided answer, and I regret that since this question came under my notice, I have not had the opportunity of re-examining those in the London collections, though here it must be noted that Mr Smith Woodward, in his "Catalogue of the Fossil Fishes in the British Museum," pt. ii., p. 247, states that the dorsal fin of *Phaneropleuron* is "single," and it certainly appears to be so represented in Huxley's figure of the finest specimen of *Ph. Andersoni* in that Museum. I feel therefore justified in provisionally erecting the Canadian species *curtum* of Whiteaves into a new genus characterised by its double dorsal fin, and for which the name *Scaumenacia* may be proposed.

Mr Smith Woodward has recently pointed out[2] that in curt the proximal interspinous elements (axonosts) of the anal fin are as in the second dorsal of *Eusthenopteron* and *Tristichopterus* fused into one piece, which is followed by three distal elements (baseosts). This is well shown in the present series of specimens, but in one splendid example, wanting the head it is true, but which originally must have been over 2 feet in length, it is also shown that a third and additional set of ossicular fin-supports followed on the second, though they are ordinarily concealed by the bases of the fin-rays.

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[1] As a matter of evolution the series would of course be reversed, *Phaneropleuron* being first and *Dipterus Valenciennesii* last.

[2] Ann. and Mag. Nat. Hist. (6), vol. xi., p. 241.

Classification.—Although the Dipnoan affinities of *Phaneropleuron* were certainly indicated by Huxley in his "Essay on the Classification of the Devonian Fishes," he placed the genus among the Crossopterygii in a distinct family of "Phaneropleurini" which he thus defined:—

"Dorsal fin single, very long, not subdivided, supported by many interspinous bones, scales thin cycloidal, teeth conical; ventral fins very long, acutely lobate."

To this family I afterwards added the Carboniferous *Uronemus*, but the cranial structure and dentition of both genera were then very imperfectly known.

Cope was, I believe, the first who boldly relegated *Phaneropleuron* to the Dipnoi; but the thing was beyond all doubt when Whiteaves showed that his *Phaneropleuron curtum* was possessed of a ctenodont dentition and an arrangement of cranial plates resembling that in *Dipterus*. That the same points hold good for *Phaneropleuron Andersoni* there cannot be any doubt, and as for the conical marginal teeth, described by Huxley, I have satisfied myself that they are merely the outer denticles of ctenodont plates. Whiteaves's statement that in *Scaumenacia curta* "both the upper and under jaw are armed with smooth conical and somewhat compressed teeth," I have never been able to confirm—at least if "marginal teeth" are hereby meant. Consequently, putting aside the older but less suitable name of Ctenododipterini (Pander and Huxley), I proposed the family term Ctenodontidæ for *Phaneropleuron*, *Ctenodus*, and *Dipterus*, but not for *Uronemus*.

For I had already in 1882 shown that the dentition of *Ganopristodus splendens*, Traq., which I afterwards merged in *Uronemus*, was NOT *ctenodont;* but that on the other hand the anterior part of the palatopterygoid bone, broad and flat, is covered merely by small rounded tubercles, while along the outer margin is one row of laterally compressed, basally confluent, short conical teeth.[1] Such an important difference in dentition seemed to me in 1890 amply to justify the separation of *Uronemus* from *Phaneropleuron* and its allies in a distinct family of Uronemidæ.[2]

Mr Smith Woodward, however, in the second part of his "Catalogue of the Fossil Fishes in the British Museum," retains the family of Phaneropleuridæ, in which he also still includes *Uronemus*. That *Uronemus* must, on account of its non-ctenodont dentition, be placed in a different family from *Phaneropleuron*, is, as I have above stated, perfectly clear to my mind at least; for the rest, the Phaneropleuridæ are separated from the Ctenodontidæ, according to Mr Woodward's definition, by the possession of marginal teeth and of jugular plates. As regards the former character, I believe it to be founded on a mistaken interpretation; as to the latter, are we quite sure that we know the structure of *Ctenodus* sufficiently well to be able to decide with certainty as to whether it had jugular plates or not?

Mr Woodward also erects a separate family for *Dipterus*, that of the Dipteridæ, the essential characters of which, as distinguished from those of the Phaneropleuridæ, are,—the absence of marginal teeth, and the hecterocercal configuration of the tail; this form of caudal fin, along with the possession of jugular plates, distinguishing it from the Ctenodontidæ. It is not necessary to repeat what has been said as to the marginal tooth question; as regards the heterocercal tail in opposition to the diphycercal form, if we accepted that as a family character in the Crossopterygian fishes we should separate genera which otherwise are most closely allied. Take the Rhizodontidæ, for example —in *Rhizodopsis* the tail is heterocercal, in *Gyroptychius* as nearly as possible diphycercal; so in like manner the most marked distinction between *Tristichopterus* and *Eusthenopteron* is the decided heterocercy of the former and the nearly perfect diphycercy of the latter. But the median fin-system of *Scaumenacia* is connected by so perfect a transition through *Dipterus macropterus* to that of the typical

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[1] Geol. Mag. (2), vol. ix., p. 543.

[2] Proc. Roy. Soc. Edin., vol. xvii., p. 393.

D. Valenciennesii, that I cannot see how it can be placed in a different family on characters based on those organs.

Consequently I must for the present still consider it the safest thing to include *Phaneropleuron*, *Scaumenacia*, *Dipterus*, *Ctenodus*, and their immediate allies in one comprehensive family of Ctenodontidæ, characterised by the possession of numerous dermal cranial roof-plates and a ctenodont dentition.

COCCOSTEIDÆ.

Coccosteus Canadensis, A. S. Woodward, Geol. Mag. (3), vol. ix. (1892), p. 483.

One plate referable to *Coccosteus*, and presumably to the above-named species, occurs in the present collection. It is the posterior ventro-lateral of the left side, and is peculiar in being narrow posteriorly, and in having the stellate based tubercles with which it is ornamented much coarser than in the typical *C. decipiens* of the Scottish Old Red.

HOLOPTYCHIIDÆ.

Glyptolepis Quebecensis, Whiteaves, Trans. Roy. Soc. Canada, vol. vi., sect. iv., p. 77, pl. v., fig. 4; A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. ii., p. 336.

The specimen here referred to is the head and anterior part of the body of a large *Glyptolepis*, the only example of the genus in the present consignment of Canadian fishes. It measures 9 inches in length, of which 5 are occupied by the head. The mandible measures 4 inches in length; small conical teeth are seen along the dentary margin, but the large laniaries are covered up. The free surface of the scales is ornamented with very fine, close, wavy ridges, sometimes irregular or contorted, but mostly longitudinal and tending to converge posteriorily, while they are also often branching and interrupted. In front of the striated portion there is a narrow, semicircular, or crescentic area of small tubercles. The scale-ornament is more delicate than in the Scottish *G. paucidens* and *G. leptopterus*, to which the fish is evidently closely allied.

Here again specific identification is a matter of conjecture, as there are no marks by which it can be positively identified with the small fish described by Whiteaves as *G. Quebecensis*, seeing that it shows neither fins nor configuration of the body, on which characters Mr Whiteaves's diagnosis was principally founded, while his specimen, on the other hand, did not display the ornamentation of the scales or cranial bones. Mr Whiteaves mentions, however, the occurrence of two large scales, showing a sculpture resembling that of the scales of *G. leptopterus*, and which he thinks may indicate a second species; he also states that, "it is however possible that they may have belonged to large and adult examples of *G. Quebecensis*, and that the specimen upon which that species is based may be a very immature individual." I accept the latter alternative in the meanwhile, rather than name a new species without sufficient warrant.

RHIZODONTIDÆ.

Eusthenopteron Foordi, Whiteaves.

Eusthenopteron Foordi, Whiteaves, Canadian Nat., N.S., vol. x., 1881, p. 31; Trans. Roy. Soc. Canada, vol. vi., sect. iv., 1889, p. 79, pl. v., fig. 5, pls. vi., vii.; R. H. Traquair, Geol. Mag. (3), vol. vii., 1890, p. 17; A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. ii., 1891, p. 362.

The present series of specimens shows the large size attained by this fish, two nearly entire examples measuring respectively 23 and 24 inches in length, and each would be at least an inch longer were the extreme point of the tail preserved.

Two points I wish to bring forward on the present occasion.

The first is the presence of a small pineal foramen on the top of the skull between the frontal bones, in the very same position as in the Osteolepid genera *Diplopterus Thursius* and *Osteolepis*, in which it has been so long known to exist.

The second is the palatal dentition. There is one large palatopterygoid bone similar to that which I figured nearly twenty years ago in *Tristichopterus*,[1] and which extends from the vomerine region in front to the articulation of the lower jaw behind. Along the anterior two-thirds of the outer margin is articulated, a row of three ossicles bearing the upper laniary teeth, and thus corresponding to the mandibular internal dentary ossicles on which I long ago showed that the laniaries of the lower jaw (except the anterior one) were borne in *Rhizodus*. There are two vomers placed behind the premaxillæ, each of which, as in the Osteolepidæ, bears a large laniary tusk. As in the Holoptychiidæ, Rhizodontidæ, and Osteolepidæ in general, the maxilla proper bears only very small teeth.

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[1] Trans. Roy. Soc. Edin., vol. xxvii., pl. fig. 3.

XIII. *Heredity and its Bearings on the Phenomena of Atavism.* By GUSTAV MANN, Esq., M.B., C.M., Physiological Laboratory, University, Edinburgh.

(Read 15th February 1893.[1])

Gebt mir Materie und ich will eine Welt daraus bauen.—KANT.

How is it that we resemble, and yet differ from our parents? What factors are at work during the union of the sperm with the ovum, to which union Fol has applied the term "fecundation"? Why should a single cell, a spore, derived asexually from a metazoon or a metaphyton, be capable of development into an organism with specific characters? According to what laws can a new individual arise by budding or by simple fission, and how can a part of an individual, if separated artificially, reproduce the whole organism?

A consideration of these questions leads up to two others: (1) given a series of species which reproduce themselves by fission, spore-formation, and fecundation, repectively, are we justified in assuming that the variability of the offspring is greatest in those individuals which owe their existence to a sexual process? and (2) how does this variability lead to the recurrence of ancestral traits, to which latter phenomenon the name of Atavism has been given?

These various questions I shall endeavour to answer from the standpoint of individual cellular physiology, and it is therefore necessary to commence with a definition of the terms "individual" and "cell."

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[1] Also read before the Darwinian Society, Edinburgh, on 9th November 1892.

An individual I consider to be any inorganic or organic substance, or group of substances, capable of maintaining—under definite conditions—its specific character. The *organic* individual differs from the *inorganic* one in having a composition which allows it not only to maintain its specific character under the environmental conditions which gave rise to its existence, but which also enables it to react on the environment in such a way that the latter, by an unbroken chain of fermentative actions, is made to pass into higher and higher compounds. Such compounds will ultimately, according to their specific chemical constitutions and affinities, give rise collectively to the different kinds of organisms.

This may be stated in other words, as follows:—The difference between an inorganic and an organic individual is simply this: in the former, the chemical affinity between certain elements, or groups of elements, has been satisfied, and has come to a standstill; in the organic individual new chemical affinities are constantly being formed, to satisfy which the organism, be it plant or animal, requires to take up food. I look upon organic existence, with all its concurrent phenomena, as the result of hunger, and hunger I have, in a previous paper,[1] defined as "an unsatisfied affinity of one element or a group of elements for another element or group of elements."

Such an organic individual is known to us in its simplest form as a unicellular being, which may be on a comparatively low grade of evolution, as the Amœba, or highly evolved, as the Infusoria, as examples of the latter I need only mention Paramæcium and Vorticella, with their cilia, oral aperture, and complicated process of conjugation. But whatever be the degree of evolution which a unicellar plant (protophyton) or a unicellular animal (protozoon) may have reached, we can always make out a differentiation of the living organic matter or plasm (protoplasm) into a number of "organs," each of which has to fulfil definite functions.

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[1] Gustav Mann, The Embryo-sac of Myosurus—Trans. Bot. Soc. Edin., 1892, pp. 351-428.

jaw behind. Along the anterior two-thirds of the outer margin is articulated, a row of three ossicles bearing the upper laniary teeth, and thus corresponding to the mandibular internal dentary ossicles on which I long ago showed that the laniaries of the lower jaw (except the anterior one) were borne in *Rhizodus.* There are two vomers placed behind the premaxillæ, each of which, as in the Osteolepidæ, bears a large laniary tusk. As in the Holoptychiidæ, Rhizodontidæ, and Osteolepidæ in general, the maxilla proper bears only very small teeth.

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How is it that we resemble, and yet differ from our parents? What factors are at work during the union of the sperm with the ovum, to which union Fol has applied the term "fecundation"? Why should a single cell, a spore, derived asexually from a metazoon or a metaphyton, be capable of development into an organism with specific characters? According to what laws can a new individual arise by budding or by simple fission, and how can a part of an individual, if separated artificially, reproduce the whole organism?

A consideration of these questions leads up to two others: (1) given a series of species which reproduce themselves by fission, spore-formation, and fecundation, ly, are we justified in assuming that the variability ffspring is greatest in those individuals which owe stence to a sexual process? and (2) how does this r lead to the recurrence of ancestral traits, to which nomenon the name of Atavism has been given? various questions I shall endeavour to answer from

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[1] d before the Darwinian Society, Edinburgh, on 9th November 1892.

As the various "organs" of a cell (*vide* Figs. 1, *2a*, *2b*), we may consider the endonucleolus, with its radiating tubes; the nucleolus; the nuclear chromatin segments; the nuclear achromatic matter proper; the cytoplasm or plasm found in the body of the cell; the attractive sphere with its central body, also known as the archoplasm and the centrosome; vacuoles; and, finally, leucites or plastids, *e.g.*, secondary nuclei, chlorophyll corpuscles, etc.

We are, as yet, far from understanding definitely what functions each of these various organs of a cell has to fulfil; still a sufficient number of facts has been established to enable us to say something definite regarding the functions of the nucleus. In a previous paper,[1] and also in the "Proceedings" of the Biological Section of the British Association, 1892, I have given a short summary of facts observed by other investigators and by myself, which have led me to the conclusion that the chromatin segments of the nucleus are organs consisting of an essential achromatic framework, in the interstices of which particles of food-material are being elaborated, and that the stainability of these segments depends on the presence of the nutritive matters in question. To put it differently, the chromatic element of the nucleus, which is so highly esteemed by most histologists, and which Strasburger, de Vries, the two Hertwigs, Weismann, etc., consider to be the ideal hereditary substance, is nothing but a supply of food on its road towards conversion into the various achromatic plasms, which latter form the essential bases of the different organs.

The nucleolus I hold to be either an organ for the further transformation of "nuclear" chromatic food-substances, or simply a storehouse for material elaborated by the nucleus.

My views are based on the following observations:—

(1) Both nuclei and nucleoli tend to occupy that part of the cell which is nearest to the supply of food, as readily demonstrated in the vegetable kingdom in the sporangia of *Tmesipteris*, *Selaginella*, and all Angiosperms, etc., and as seen in the animal kingdom in the ganglion cells of the

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[1] Gustav Mann, The Embryo-sac of Myosurus—Trans. Bot. Soc. Edin., 1892, pp. 351-428.

retina of the Salamander, in the alimentary canal of the same animal, during the early development of the chick, etc.

(2) On the staining reactions of nuclei and nucleoli during the various phases of cell-life, as seen in the accompanying table.[1]

Cell.	Nucleus.	Nucleolus.
During "rest," *i.e.*, not dividing,	Blue.	Red.
During division, ...	Red.	Colourless.
During senescence, . . .	Red.	Red.
In the ovum, ...	Blue-red.	Red.
In the spermatozoon, . . .	Blue.	Not demonstrable.
In fungi, ...	Red.	(?)

The following explanation is offered: "We must suppose that the new material which is first conveyed to the nucleus will take on a blue stain, and that this cyanophilous substance is converted in the nucleus into an erythrophilous material, which latter is then carried to the nucleolus, because, during senescence, division and other conditions (at maturity of the ovum), when the cell may be supposed to be less actively assimilating food-materials from without, we have, invariably, a red coloration taken on by the nuclear chromatin. This supposition would also explain why the spermatozoon, owing to its great activity, is not able to lay up a store of elaborated material, and therefore why it should stain blue;

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[1] Differential nucleolar staining was first put on record by Guignard in 1885 (Ann. Sci. Nat., sér. 6, t. xx., p. 318). Flemming demonstrated this fact, however, in 1884 at the Copenhagen Medical Congress, as he states in his latest paper: Neue Beiträge z. Kennt. d. Zelle, 24th April 1891 (Arch. Mikr. Anat., xxxvii., p. 697); *vide* also Hermann in April 1889 (Arch. Mikr. Anat., xxxiv., p. 60); and G. Mann's paper, January 1891 (Trans. Bot. Soc. Edin.). L. Auerbach first pointed out the differences between the nuclei of male and female reproductive organs in *Cyprinus*, *Esox*, *Triton*, *Rana*, *Lacerta*, and *Gallus*—S. B. K. Preuss. Akad. Wiss., 1891, p. 713. F. Rosen confirmed Auerbach's observations for monocotyledonous plants, and also pointed out the staining reactions of the nuclei in fungi. Paul Schottländer confirmed them for Cryptogams (Bericht. d. Deutsch. Bot. Gesell., 1892, p. 27).

and why Fungi, which live on organic material, *i.e.*, on already elaborated matter, have so great an affinity for the red or acid dyes.

To the endonucleolus with its fibres, and to the attractive sphere with its corpuscle, I had attributed trophic functions in my last paper, but M. Heidenhain's[1] researches have since shown that the centrosome may be looked upon as a centre for locomotion, as in the white blood-corpuscles of the Salamander delicate threads, which are apparently contractile fibrils, can be traced from the corpuscle to the very periphery of the cell. We know further, since v. Beneden's and Neyt's researches, that during division of the cell—when the fibres proceeding from the corpuscle are most readily seen—these corpuscles are the active agents bringing about a separation of the chromatin segments, which have previously undergone either a longitudinal or a transverse division.

To the endonucleolus I can also no longer attribute trophic functions, as I now believe it to be not a centre comparable to the nervous system of higher organisms, but rather a space from which channels pass in various directions, these channels serving for the distribution of elaborated and easily assimilable materials.

Of the various organs of the cell, none are better known than the chlorophyll granules or chloroplasts. We know that they are concerned in the production of starch, that light is essential for this process, as is also, in all probability, iron, etc.; but I cannot now enter more fully into a description of the various cell organs. What I have stated will be sufficient to show that a cell is a highly organised individual, and not a bag containing an "emulsion" of *proto*plasm, as some still fondly believe, who, ignorant of histological methods, explain all microscopic appearances as artefacts, and who taunt the histologist by exclaiming: You can't "fix" protoplasm!

The working of the cellular machine I cannot illustrate better than by referring to the views of Max Verworn,[2]

[1] v. Kollicker's Festschrift, Würzburg, 1892.

[2] Max Verworn, Arch. f. Physiol., vol. 51, pp. 1-118.

who published an exhaustive account of his experimental researches on Infusoria—researches specially undertaken to throw light on the functions of the nucleus. This author has arrived at the following conclusions:—"The physiological significance of the nucleus is dependent only on its relations to metabolic changes occurring in other parts of the cell. It influences the functions of the cell only by the part it plays in the metabolism of the cell, and only hereby does it take an active part in the phenomena of cell-life." "A nucleus cannot exist without its protoplasm, nor can the protoplasm exist without its nucleus—they are both mutually interdependent."

Verworn illustrates his view by the accompanying figure, which represents a cell with its nucleus. Each arrow indicates a set of nutritive materials in process of metabolism. The cell receives a number of materials from without, a portion of which (*a*) is acted upon by the cell protoplasm; analytic and synthetic changes are brought about which lead to a part of the absorbed material being got rid of as effete matter (*b*), while the remaining portion is partly made use of by the cell-plasm (*c*), and partly conveyed to the nucleus (*d*). The nucleus is represented as further receiving certain substances from the exterior, which pass unchanged through the cell-plasm (*e*). Those substances (*d* and *e*) which reach the nucleus, in their turn undergo metabolic changes—they are partly made use of by the nucleus itself (*s*), partly handed over to the cell-plasm (*h*), and partly removed as effete matter (*f*).

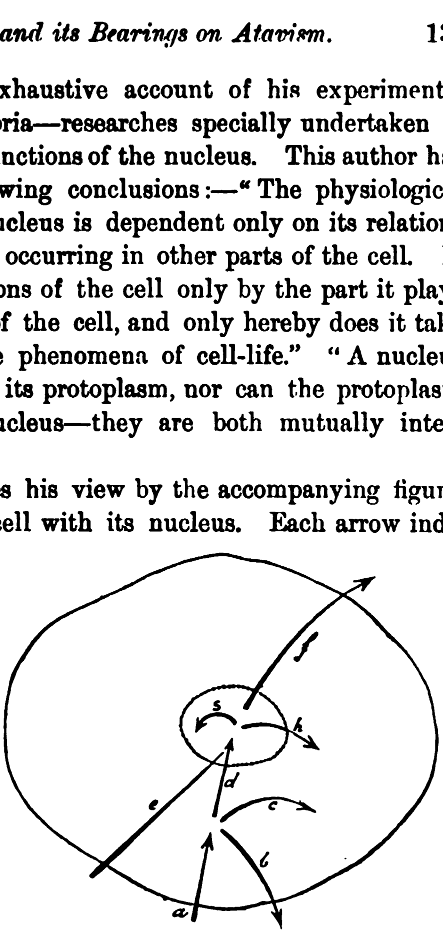

Fig. 3.

Fig. 3.—Diagram of cellular metabolism. (After Max Verworn.)

The diagram fully illustrates the conceptions of Verworn, and his views I endorse. There exists in each cell an intimate relationship not only between the nucleus and its protoplasm, but also between all the organs of a cell; and as long as this relationship is not broken, and as long as the equilibrium between the various organs is not upset, so long will the cell be able to live an individual and immortal life.

Theoretically, a happy state such as that just depicted is conceivable; in nature it does not occur. No individual is immortal, for the very existence of a cell depends on a perpetual change of lower (inorganic) into higher (organic) chemical compounds; and if the term individual be given to such a chain of progressive metamorphoses occurring within the definite organs of a cell, any cause leading to a disruption of the normal processes must also lead to a loss of that particular individuality. Thus a cell which either undergoes division, or which fuses with another cell in the act of fecundation, loses its individuality, though the chemical constitution of the various plasmata occurring in the cell is preserved, and thus the perpetuation of the species ensured.

Let me repeat, that a cell will not divide or fuse with another cell as long as the equilibrium between its various organs can be preserved, *i.e.*, as long as its individuality is not threatened.

After this short sketch of cellular physiology, let us consider how parental traits are propagated.

In a unicellular organism, as represented by Verworn's figure, we have to deal with an individual relying on its own resources, and living an existence which is independent of other representatives of its own species. It is not difficult to understand how such an organism is able to propagate its specific characters either by budding, as in the yeast, or by ordinary division (amitotic and mitotic), as in the case of Amœbæ and white blood-corpuscles, provided that during budding or cell division all those organs are handed on which are necessary for the maintenance of the individual in question; and we know for certain that during budding and division the various cell organs are indeed handed on. An artificial division of such unicellular organisms is theoretically also possible if it be conducted in such a way as to ensure the presence of the same set of organs in each fragment.

The *sexual propagation* of unicellular individuals is also not difficult to understand, for it depends on the transmission of cell organs derived from two distinct and individual cells; the smaller, more active, and starving one being the male cell; while the larger, less active, and overfed one is termed the female cell.

That which *is* so difficult to understand in fecundation is the associated reduction in the number of cell organs. Thus in *Spirogyra nitida* each cell possesses four spirally twisted chlorophyll-bands, the fate of which, in conjugating cells, is highly interesting. The contents of one cell pass by a bridge-like junction into another cell; then a fusion of the nuclei occurs analogous to that of other sexual cells, but four out of the eight chlorophyll-bands soon degenerate and become used by the newly-formed cell or zygote, which in this way maintains the normal number of four bands. It is important to note, that the four bands which disappear always belong to the active or male cell, and this fact seems to me a further proof of the correctness of my hypothesis, that fecundation consists in the union of a starved cell with an over-fed one.[1] The starved or male cell in the instance under consideration, is the result of the inefficiency with which the chlorophyll-bands perform their function of providing the cell with carbohydrates.

Spirogyra is thus an example of the fact that *in an offspring the various organs derived from two distinct cells rearrange themselves so as to fulfil their physiological function to the greatest mutual advantage.*

Amongst other cell organs transmitted from parent to offspring must be mentioned the attractive spheres and their corpuscles, the nuclear achromatin (both the darker peripheral and the paler perinucleolar parts, distinguished by Frommann), the nuclear chromatin segments, the nucleoli and endonucleoli.

[1] G. Mann, The Embryo-sac of *Myosurus minimus*, a cell study. With two plates.—Trans. Bot. Soc. Edin., 1892, p. 399-424.

Fol, v. Beneden, Boveri, Guignard, and others[1] have established, for both animal and vegetable cells, the fact, that during fecundation the paternal and maternal attractive spheres play an important rôle, especially in bringing about an equal division of the two sets of organs derived from the father and mother respectively. How this is possible we may learn from the observations of Fol and Guignard, who found that a union of paternal and maternal attractive spheres takes place during fecundation. Given then, firstly, a set of "male" and "female" attractive spheres; secondly, an affinity of each sphere for its own male or female nuclear elements; thirdly, a union (*not fusion!*) of the two sets of spheres derived from the sperm and ovum; fourthly, a division of the newly-formed sphere ("zygote sphere") in such a way that each daughter-sphere receives its share of maternal and paternal elements,—it then follows that on division of the "zygote" nucleus (*Furchungskern*, Hertwig), formed by the fusion of the paternal and maternal half nuclei (demi-nuclei), the nuclear segments will be divided in an equal manner between the two daughter-attractive spheres.

I need hardly mention that the distribution of the nuclear segments will take place in quite an analogous manner in those cases where the two demi-nuclei do not pass through the stage of a "zygote" nucleus, but where they participate at once in the formation of the first division spindle (*Furchungsspindel*, Hertwig), as, *e.g.*, in *Ascaris megalocephala*. But to this different behaviour of the sperm and egg demi-nuclei I have to return afterwards, for as yet I have spoken of demi-nuclei without explaining how they arise.

In animals and plants, in the lowest as well as the highest, we find that cells which are going to become sexual cells, pass through a certain stage, after which they will give rise, by a thrice repeated division, to eight sexual cells, and therefore we may call this stage that of the *grandmother*-cells. If, now, a grandmother-cell possesses a nucleus with four chromatin segments, these are found to split longitudinally, and thus to form eight segments, four of which go to either

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[1] For Literature, *vide* my paper on the Embryo-sac of Myosurus, etc.

mother-nucleus. The two mother-cells, by a similar division, give rise to four *daughter*-cells.

Each daughter-cell, however, which is going to become the mother-cell of two sexual cells, does not undergo division in the usual manner, *i.e.*, its nuclear segments do not undergo a preliminary division, but are simply distributed between the two sex cells, each of which will therefore receive only two segments. This reduction in the number of chromatin segments is characteristic of sex cells, and as, further, the reduction is always equal to half the number of segments found during the non-sexual condition, it is justifiable to call the nuclei of sex cells, half or demi-nuclei.

A grandmother-cell will thus always give rise to eight sex cells, but the fate of these latter will depend on whether they are to become male or female cells. If they are to be male cells, all the eight will, as a rule, attain maturity, while, if the grandmother-cell give rise to an egg, only one cell is fully developed, the ovum proper, while the three others are non-functional, and are termed the polar vesicles or *Richtungskörper*.

That only one-half the number of the chromatin segments found during the non-sexual condition is handed on from both parents is a well-established fact; and I only wish that as sound an explanation could be offered, but as yet we are not able to do so. All teleological considerations, such as those offered by Weismann, have, of course, to be put aside. A sperm-nucleus or an egg-nucleus does not get rid of one-half the number of its segments to prevent overcrowding of ancestral qualities or predispositions, and at the same time to make room for the nuclear segments of the other sex. We must rather look out for some phase in the life-history of lower unicellular organisms in which a reduction of nuclear segments is found quite apart from any sexual act, *e.g.*, perhaps during the zoospore stage, for I believe that fecundation is only a secondary adaptation between cells, the organs of which have become reduced in number or efficiency by some intrinsic or extrinsic factor which is detrimental to the normal existence of cell-life. As such a factor we might consider any cause leading to diminished metabolic changes within a cell; thus the amount of available food-material may diminish, or the ease with which food is absorbed may be interfered with.

Thus a cell containing two attractive spheres, and a nucleus with four nuclear chromatin segments, would have greater difficulty in obtaining and absorbing food than a cell with only one sphere and a nucleus with two segments, because of the well-known principle first applied to Biology by Leuckart and Spencer, that the surface of a growing spherical cell increases as the square, while the contents increase as the cube of the radius.

We have thus far seen that "cell organs" such as chlorophyll-bands, attractive spheres with their central corpuscles, and chromatin segments, are transmitted from parent to offspring, but that also the general cell-plasm and the nuclear achromatins, nucleoli and endonucleoli, are transmitted I have fully proved for the conjugating cells within the Embryo-sac of Angiosperms, cells which give rise to the primary endosperm nucleus. The stages in the formation of the latter in *Myosurus minimus* may be summed up thus:—

1. Amœboid movements of the cell-plasmata of the two primordial (*i.e.*, naked) cells, leading to conjugation of the cell-plasmata.
2. Approximation of nuclei and formation of paranucleoli or accessory nucleoli, which probably undergo degeneration.
3. Flattening of nuclei on contact, and absorption of intervening nuclear membrane.
4. Conjugation of nuclei (union of the various contents of both nuclei).
5. Approximation of nucleoli (due to contractile action of threads within the nucleus ?).
6. Conjugation of nucleoli (and in all probability of the endonucleoli). Casting off of (male ?) nucleolar bag.

What is of special interest in this fecundation is not the mere transmission of nucleoli, but the fact that we should meet with not only a reduction in the number of chromatin segments, but also with a diminution in the amount of nucleolar matter, as the latter, especially in the ovum, gives rise to a number of paranucleoli or accessory nucleoli, which gradually lose their chromatin, leave the nucleus by passing through the nuclear membrane, and then become ultimately absorbed. Again, the remarkable fact of the nucleolar membrane of the "male" nucleolus being shed, reminds us of the fate of the four "male" chlorophyll-bands in the zygote of *Spirogyra nitida.*

How great the activity of endonucleoli is, may also be gathered from my paper, but now I must restrict myself by returning to a consideration of how the "male" and "female" demi-nuclei behave during fecundation. I stated above (p. 134) that there may be either a union of the two demi-nuclei to form a resting nucleus ("zygote" nucleus or *Furchungskern*), or that the nuclear contents may take part directly in the formation of the nuclear spindle (*Furchungsspindel*). In the latter case the attractive spheres exert their influence at once, while in the former case the zygote remains dormant for a time, in some instances probably because of want of nourishment, *e.g.*, the primary endosperm nucleus of Angiosperms remains quiescent till an extra supply of nourishment is conveyed to the ovule as the result of the irritation set up by the fecundation of the ovum. At any rate, I should conclude theoretically that *the zygote cannot undergo division till an equilibrium between the maternal and the paternal "cell organs" has been established;* and this balance I stated in my last paper to be brought about thus: the starving cell organs of the male cell feed on the surplus nourishment stored up in the female cell, and in consequence they increase in size till they are quite as large as the female organs, an observation readily demonstrated in the Embryo-sac of Angiosperms, in which the small spindle-shaped male nucleus derived from the pollen-tube ultimately becomes of the same size as the large globular female nucleus.

During this stage of fecundation, then, the male cell must be looked upon as truly parasitic in its habit, and it is this very parasitism which reduces the available amount of nourishment in the ovum, and which calls forth the activities of the female cell organs. The latter find themselves passing from abundance to privation, while the male organs are transplanted in a starving condition into the midst of exactly that kind of nourishment which they will have the least difficulty of assimilating, because it was formed by an individual of the same species.

Sooner or later the "directly" available nourishment is used up, and the activities of both the male and female organs will be called forth to the same extent; their union results, and the new combination of organs leads to a special activity, to the division of the cell.

By the above condensed account of the phenomena of fecundation, I wanted to show that—

(1) In an offspring *all* "cell organs" are *directly* transmitted;
(2) These organs will tend to rearrange themselves in such a way as to give the offspring the same organisation as that possessed by either parent.

With these two premises it is not difficult to see why an offspring resembles its parents, for both progenitors and descendants have the same organic constitution, which forces them to exhibit the same phenomena during life. Why the offspring may differ from its ancestors is another question, and this I shall attempt to explain afterwards when alluding to the higher forms of organic existence.

THE ORGANISATION OF METAZOA AND METAPHYTA.

As we ascend the scale of life we meet with species consisting of more than one cell; from Protozoa and Protophyta we pass on to Metazoa and Metaphyta; but what factors played a part in bringing about this evolution is one of the most difficult problems a biologist can encounter. I am fully aware of the impossibility of settling this question, but I hope that the suggestion I am about to offer may bring us a step nearer the solution.

We saw how complicated an organisation belongs even to the lowest forms of life, and that the various organs in individual cells occur in multiple numbers, *e.g.*, the chromatin segments of the nucleus are at least two in number, as in

Ascaris; while in some cases they may number a hundred or even more. If now an organism possess, say, several chromatin segments, and if it undergo evolution, it is conceivable that the metabolism may become evolved along such divergent lines that the proper performance of *all* the functions by each single segment becomes difficult if not impossible. Further, as the various segments in a nucleus are not under conditions identically the same, I infer that each segment will evolve along such lines as are facilitated by its relative position in the organism.

Thus we would be dealing with the following factors:—

1. A unicellular organism possessing several nuclear segments, each of which fulfils functions somewhat different from those performed by the other segments.
2. A division of functions between the various segments, allowing progressive or evolutionary changes to take place more readily in each segment.
3. The sum total of metabolism raised in the nuclear segments.
4. Corresponding evolutionary changes in all the other cell organs.
5. The cell-metabolism rendered more and more complicated.

Given such a cell with a very complicated organisation, and with its various plasmata consisting of comparatively unstable compounds ready to undergo further evolution, we can understand how a division into two equally organised daughter-cells will become gradually more and more difficult, and ultimately impossible. The unicellular organism must therefore give rise to two daughter-cells which differ in some respects from one another, and the fate of the latter I can perhaps best explain with the aid of Verworn's figure (p. 131).

If a cell *x* divide into two cells A and B, of which the cell A is especially abundant in "nuclear" matter, while the cell B is rich in cell-plasm, it is evident that both cells will metabolise materials, essential to the life of each cell, but in varying quantities. The cell A, rich in "nuclear" matter, will especially elaborate the substances *s* and *h*, while the cell B, rich in cell-plasm, will form proportionally larger amounts of the substances *c* and *d*. We know further, from my researches on the "Embryo-sac of Angiosperms," that each daughter-cell commences to feed a long time before separation from its sister-cell has taken place, and therefore there is nothing to hinder a ready interchange of substances between the two daughter-cells A and B. This interchange being of direct benefit to both individuals, will tend to prevent a complete separation of the cells A and B; thus a unicellular organism will become a two-celled one, and by a repetition of the process just suggested, we may derive the higher multicellular organisms from originally unicellular ones.

WHAT CONSTITUTES INDIVIDUALITY AMONG METAZOA?

We began our consideration of unicellular organisms by defining the terms "individual" and "cell," and it was found that these two terms were co-extensive amongst Protozoa and Protophyta; but amongst beings consisting of more than one cell, a new definition of the term individual is required. Why then is a Hydra, a Starfish, or a Begonia plant termed an individual, and how is it that parts of these organisms may give rise, under certain conditions, to new and entire beings, which are in all respects identical with the respective mother individual?

I endeavoured to show that a multicellular condition is the outcome of evolved metabolism, and we may therefore define a multicellular individual as a being in which the various processes necessary for life are distributed amongst a collection of cells, instead of being performed by the various organs of a single cell. Thus if we represent in a protozoan individual the functions of the various cell organs and their equilibrium by the letters $\mathrm{a} + \mathrm{b} + \mathrm{c}$, then in a Metazoon consisting of three cells, an ideal division of labour might be shown thus: $\mathrm{Abc} + \mathrm{aBc} + \mathrm{abC}$, the capital letter standing for the special function performed by each cell. Further, should a Metazoon have the same functions, but consist of more than three cells, then we would have to write: $(\mathrm{Abc})^{n} + (\mathrm{aBc})^{n} + (\mathrm{abC})^{n}$. In this latter case we must also bear in mind the anatomical arrangement of groups of cells differing in their functions, *e.g.*, are we dealing with a concentric arrangement as in the Hydra, in which the ectoderm, the mesoglœa, and the endoderm are placed one within the other; or have we a bilateral, a dorso-ventral, or an antero-posterior grouping?

Apart from this *primary* arrangement of tissues, we may have a *secondary* organisation, for we may find the same anatomical distribution of all the organs in different parts of the same individual, *e.g.*, in the Starfish, with its pentaradial system, each arm with its corresponding part of the disc resembles its neighbour; in plants, *e.g.*, Begonia, the tissue of each leaf is divided into a dermatogen, a periblem, and a plerome.

Finally, some of the organs of a multicellular being may occur in multiple number, while other organs are only found singly, thus the segmental organs of a worm and the eyes of vertebrates are bilateral, while there is, apparently, only one ventral gangliated chain in the former, only one heart in the latter.

The bearing of these facts on Heredity will become evident immediately.

If a Hydra, a Starfish, or a Begonia plant be individuals, how is it that parts of these organisms may give rise, under certain conditions, to new and entire individuals? for if the arm of a Starfish, with its corresponding portion of disc, be cut off, this arm is found to have the power of developing into a complete individual. If a Hydra be divided into several fragments, each of these may give rise to a complete Hydra; again, portions of Begonia leaves are daily used for propagating this plant.

An explanation of this propagation of individuals must account for two facts, namely, *firstly*, how is it that a portion of a mother-individuum can live after being separated artificially, and *secondly*, why should the fragment assume the shape of the mother-individuum, *e.g.*, why can an arm of a Starfish live by itself, and why does it give rise to four other arms, thus re-establishing the pentaradial form?

We saw above that each arm of the Starfish contains all the organs essential for maintaining an individual, and as these organs can elaborate food independently of the presence of the corresponding organs in the other four arms, it is not difficult to see why one arm may continue to live. Why it forms four other arms is, however, a question I cannot, as yet, attempt to answer.

Hydra and Begonia, for reasons similar to those advanced for the Starfish, are, on being cut into fragments, capable of giving rise to several individuals; provided that each of these contains all the tissue elements, and that, in addition, each be protected by a certain bulk from detrimental environmental conditions; which latter may overcome a small aggregation of cells more readily than a large one.

Such an organism, allowing of a division of the mother-individuum into a number of daughter-individua, may be said to be built up of "potential" individuals. Each "potential" individual being an aggregation of cells that would be able, under normal environmental conditions, to survive and to give rise to an individual like the mother;—and this latter might be termed a "real" or "actual" individuum.

Such "potential" individuals inherit the characters of the actual or "real" individual, by receiving all the tissue elements of the latter. It is different, however, when an individuum propagates itself on its own account.

A Metazoon consisting of three cells, which differ in their functions (Abc + aBc + abC), cannot reproduce its kind by budding off a single cell, for the bud would have to be derived from a cell, in which division of labour has produced the special development of an organ, and such a cell, if really budded off, could not perform its physiological functions under ordinary environmental conditions. Theoretically, such a bud could only live if it lost the special function acquired by its mother-cell—or if the environment was changed. That such a Metazoon could give rise to a non-specialised bud by a modified process of cell-division, is, I think, impossible.

As long as a special function is bound up in the organs of a single cell, the latter cannot give rise to a new or real individual; but if the same function be performed by a number of cells, it is conceivable that one of these may gradually lose its special character and become an initial cell, which will give rise to a new organism, or what is even more likely, that it will never acquire its special function.

A process like that just suggested appears to occur in the Hydrozoa, in which a single ectoderm cell may give rise to a bud, or develop into sexual cells; but how the loss of specialisation in an ectoderm cell is brought about, cannot be stated definitely. It would appear to depend on the respective cell benefiting by the labour of the other cells, becoming, in fact, parasitic. As there are a number of cells in the ectoderm, the mesoglœa, and the endoderm elaborating nourishment collectively, we can readily suppose a cell to feed on this elaborated material, if either its organisation be defective in the organs required for its special functions, or if its special function remain dormant, as the neighbouring cells are capable of satisfying all the requirements of the individual.

This occasional non-specialisation of cells amongst low forms of life, *e.g.*, in the Hydra, has developed amongst higher beings along definite lines, and the "non-functional" cells are aggregated into special organs, and we are wont to distinguish between the "somatic" cells, which have undergone specialisation for maintaining the individual, and the "generative" or "sexual" cells, which bring about the perpetuation of the species.

From my standpoint it is evident that the non-functional cells, which become the sexual cells, will depend for their existence on those food materials which are being elaborated by the differentiated, functional, or somatic cells, and therefore that sexual cells are influenced by the soma of the individual in which they live.

Any change in the functions of the various organs concerned in the elaboration of food-materials must lead to an altered nutrition of the whole individual, the sex cells included; and provided the change is not sufficiently great to kill the soma of the individual, and provided the sex cells are not fully matured (*i.e.*, that they are still young enough to be affected by the change in nutrition), it is evident that the latter will also be altered. As, further, the organs of the reproductive cells are modified, it stands to reason that the embryo derived from them must be modified.

Theoretically, acquired characters can therefore be transmitted. I need hardly say I would not acknowledge the loss of a tail, *e.g.*, in the dog, to be a character capable of influencing the offspring of that dog, for the very simple reason that the tail has nothing to do with the elaboration of food-materials.

THE MAIN FACTORS IN SEXUAL REPRODUCTION would appear to me to be shortly these:—

1. The sex cells being parasitic do not undergo any special development, and are accustomed at the same time to definite kinds of food-materials elaborated by the soma of the individual.

2. Fecundation leads to the union of sets of elements derived from different parents, the organs rearranging themselves to their greatest mutual advantage.

3. Thus a vigorous unicellular individual is formed, having a number of "cell organs" with a definite chemical constitution, and accustomed to be supplied with a definite kind of nourishment.

4. Next, an endeavour to assimilate food-materials in the accustomed form and quantity, and as the individuum has to assimilate its own food, having lost its parasitic nature, a development of special functions, which latter during ontogeny will be successively distributed over "cell organs," cells, and ultimately groups of cells (*vide* above, pp. 139, 140).

5. But not all the cells derived from the zygote or fertilised ovum will undergo a special development for mutually benefiting one another, and these will commence as soon as possible to revert to or maintain their parasitic nature, and develop again into reproductive cells.

VARIABILITY.

That the offspring differs more or less from its parents is [illegible]veryday observation, and to our eyes the variability of the descendants seems to increase as we ascend in the scale of life, the modes of reproducing the individual becoming more and more complicated. Variability is quite conceivable in a budding Hydra, but it does not strike us as does the disparity in bodily features and mental traits so often shown by father and son.

Above (pp. 136, 137) I have shown that in each species the number of " cell organs " is a fixed one, and that in fecundation the nuclear chromatin segments, and probably most of the other organs, are always reduced to one-half their normal number.

One readily sees that a zygote containing the normal number of " organs," which are derived from two different sources, will be liable to greater variations than a cell derived asexually (a spore), for the following reasons :—

(1) There will be a reaction upon one another of the various "cell organs" derived from the sperm and ovum; and

(2) A reaction of the environment, which may be more favourable either to the set of paternal or to the set of maternal organs, throughout ontogeny or during part of the same.

(3) We have to take into account the relative vigour of individual cell organs handed down from the two parents, *e.g.*, all the organs of one parent may be relatively weaker than those of the other parent, or only some organs of one parent may be weak, while the others are specially strong.

This variability must lead of necessity in extreme cases to great difficulty in elaborating food-materials to the mutual benefit of all the cell organs, and such a difficulty makes itself felt in the case of cross-fertilisation, the hybrid being in many cases sterile, probably because the food elaborated is not of such a nature as to satisfy the requirements of any one cell, which therefore cannot remain non-functional and thus become a sex cell, or even if the sex cell be formed, the vigour of the individual cell organs will be so much weakened or disturbed as to make fertilisation impossible.

ATAVISM.

Atavism, or the recurrence of ancestral traits, may be explained, if the above conjectures be correct, thus :—We know that cell organs are transmitted during fecundation, and that they have definite functions to fulfil; and we may assume that the *features* of an individual depend on the manner in which the various functions necessary for life are fulfilled by the cell organs.

Thus in a zygote, the "paternal" nuclear segments will meet their homologues, the maternal ones, and theoretically one of the following events may occur:—

(1) The maternal and paternal organs, *e.g.*, chromatin segments, may be equally vigorous; they may be equally affected by the environment, and they may carry on their work in harmony. If this be the case, the embryo, on reaching maturity, will be unlike either parent, for its *features* will be the result of the blending of those seen in the parents.

(2) The segments derived from one parent, say the mother, may be *primarily* the stronger or more vigorous, and the environment may suit them better than it does the "paternal" segments. Hence during ontogeny the maternal cell organs will undergo a special development, and will provide the embryo with such nourishment as the mother-individuum was accustomed to, and the embryo will show in a more or less pronounced form the *features* of its mother.

This influence of the maternal cellular organs extends, however, not only to the embryo as an individual, but also affects the paternal cellular organs, which latter may be strengthened or still further weakened.

We have also seen above that mature sex cells contain only one-half the number of chromatin segments possessed by either the immature sex cells or the somatic cells.

The question arises, What will be the distribution of the segments at the time of formation of the mature sex cells? Let us consider the case of *Ascaris megalocephala*, the immature sex cells of which contain four chromatin segments, two of which were derived from the father, while the two others were got from the mother. These four segments may evidently be distributed in such a way that each mature sex cell receives either the two maternal or the two paternal segments, or one maternal and one paternal segment.

Which it does receive will depend, firstly, on the number of fully formed sex cells which reach maturity—thus in the ovum only one sex cell out of a possible of eight matures, while normally all eight male cells become spermatozoa; and secondly, on the vigour of the respective male and female segments.

In the ovum I should suppose those segments to remain which were the strongest, either male or female ones, or if these be equally strong, one male and one female. In the spermatozoan, if division be equal, I should expect one paternal and one maternal segment respectively. From my standpoint then, *the male cell gives rise to greater variability than the female cell.*

The reappearance of the characters of the grandparents would seem to depend on the special development of those segments derived from the respective grandparents. If, *e.g.*, a female individuum A receives two chromatin segments w and x from its father, and other two y and z from its mother, we may assume w and x to be less vigorous than y and z; and this circumstance would call forth a special activity of y and z, with the result that A would resemble its mother more than its father. A on forming her sex cells would retain in the ova the more vigorous segments y and z, and these, should they meet again with feeble male segments, will have been exercised during their existence in A to such an extent as to impress in a very marked way their characteristics on the new individuum B, which latter will show in a correspondingly evident manner its resemblance to its grandmother.

Another possibility, however, is this, that the segments y and z may have been weakened through having been forced to work in company with the still feebler w and x. If this be the case, and if they meet during fecundation vigorous male cells, they will be able to play only a second role during the ontogeny of B, and then the male cellular organs will make their supremacy felt. Again, however, the traits of one grandparent will tend to predominate.

Partial Atavism, *i.e.*, a resemblance to grandparents in *some* points, may similarly be accounted for on the supposition that, during ontogeny, either the paternal or the maternal cellular organs undergo a special development in the respective organs of the metazoon or metaphyton.

XIV. *The Ancient Lake of Elie.* By James Bennie, Esq., and Andrew Scott, Esq.

(Read 19th April 1893.)

PART I.

By James Bennie, of the Geological Survey of Scotland.

The deposits which first proved the existence of this ancient lake were laid open in making the East of Fife Extension Railway in 1863, and the earliest published notice of the lake peat deposits with fresh-water shells is contained in a communication by the late Rev. Walter Wood, of Elie, read to this Society on 25th November 1863, and published in vol. iii., page 125, of our *Proceedings* for 1863-64. As Mr Wood's paper consists of a general description of all the strata cut through by the railway from Kilconquhar Station to Anstruther, a distance of six miles, the notice of the lake deposits is brief, and may be given in Mr Wood's own words:—"Above the clay (containing the Arctic shells) is a layer of peat, which first appears in the cutting between the bridges (the bridge under the Kilconquhar road and the Elie station bridge) as several thin seams with sand (apparently blown sand) intervening. They dip rapidly toward Elie station, where they form a bed of peat not less than 10 or 12 feet thick, mixed with much sand and many fresh-water shells."

The next notice of this lake peat with shells is contained in a paper by the late Rev. Dr Thomas Brown "On the Arctic Shell Clay of Elie and Errol, with other Local and more recent Deposits," read before the Royal Society of Edinburgh, 4th March 1867, and published in the *Transactions*, vol. xxiv., page 617. Dr Brown gives a section as exposed in the cutting from Elie Station westward to the bridge under the Kilconquhar road, the upper part of which consisted, he says, "of blown sand of very considerable depth;" and adds, "all through it contained numerous dark layers, showing former surfaces, and containing land shells, especially the *Succinea putris*. Besides these there were intercalated, at four or five different levels, beds of peat (marked in the section *a, b, c, d, e*). The uppermost of these is 6 feet in depth. They are all full of land and fresh-water shells, to which I shall afterwards refer." Dr Brown's after reference is as follows:—" Of the blown sand by far the best display is at the railway station, where, from the highest point of the synclinal down to the base of the deposit, there must be at least 20 to 30 feet of perpendicular depth. The highest bed of the enclosed peat is about 6 feet thick. The growth of the peat at its different levels, and the accumulation of this sand, shows that the lower portion of it must be of considerable antiquity. The great feature of the deposit is the profusion of land and fresh-water shells in the peat. I examined the last bed with some interest to ascertain whether any of the species were extinct, but found only the following:—

Succinea putris.
Limnea peregra.
Zua lubrica.
Pisidium pulchellum.
Cyclas cornea.
Carychium minimum.
Helix nemoralis.
,, *fulva.*
,, *fusca.*
,, *pulchella.*
Pupa muscorum.
Planorbis marginata.

These are all recent, and most of them have actually been found by Dr M'Bain, living near Elie. The only thing to be observed is that the immense number of these shells found in the peat seem to show that there formerly prevailed some peculiarly favourable conditions for the development of this form of life. At the same time it is clear that the climate must have been much the same as now, for the species are identical."

These descriptions are given in full, because Mr Wood and Dr Brown had opportunities of seeing these lake peat beds with shells when exposed from top to bottom in the railway cutting, and could, in consequence, judge better of the conditions under which they were formed than I—who have only seen it in or got it from chance diggings for drains, etc.—could possibly do, and therefore their descriptions possess an authority which mine cannot have.

My attention was specially directed to this shelly peat at Christmas 1889, when at Elie collecting specimens of the submerged forest bed, by being told by Mr Affleck, station-master there, that a peat with shells was to be found at the south side of the station, and he showed me the place; but being too heavily laden with the other peat I could not take any with me then, and had to ask Mr Affleck to send some to me. This he did, and I washed and examined it, and found it was the same kind of peat with shells described by Mr Wood and Dr Brown. At the Easter holidays of 1890 I returned and got a large quantity of it, Mr Affleck helping me to dig it out. This I washed and examined, and handed the shells to Mr Thomas Scott, F.L.S., for determination, and he, finding them interesting on several accounts, read a note on them to this Society, which is published in vol. x., p. 337, of our *Proceedings*. Mr Affleck has since sent me several large lots of this shelly peat from five other exposures—one from the foundation of a new crane at the station, two from the east end of the High Street, one from Bank Street, opposite Professor Greenfield's house, and one from the road to Elie Harbour. The quantities sent were large, sometimes more than a hundredweight, so that our opportunities of research have been great, and the results obtained very satisfactory.

The material in which the shells occur may be described as earthy peat or loam mixed with sand,—seashore sand blown into the lake from the shore. Sometimes the peat was very pure, and in it the shells were few, but generally it was much mixed with sand, and in these portions the shells were most numerous. The material from the east end of Elie—the station peat—the two samples from the High Street, and that from the Harbour Road, had very much peaty matter in them, while that from Bank Street consisted chiefly of sand with only a sprinkling of peaty dust, from which it may be inferred that the lake was deepest in the eastern part and less so in the western, or it may be that the western part was more exposed to the winds which blew the shore sand into its waters. The peat, which is decidedly a water peat, consisted chiefly of mud with vegetable fibres in it—the result of slow maceration in water. Occasionally fragments of hazel nuts occurred. Seeds were not numerous, except such as from their woody nature best resisted decay, such as the nutlike bog beans, and those of the carices. The seeds were submitted to Mr Clement Reid, of the Geological Survey of England, and I append a list of them as determined by him.

Of the animal life that existed in this lake the most frequent were the land and fresh-water shells. Their abundance is alluded to by Mr Wood in 1863, but is stated more emphatically by Dr Brown in his paper in 1867, as already quoted. In the samples I examined, they were equally abundant in all the five places, and generally in good preservation. Other remains of animal life were present, such as the cases of caddis worms, sometimes composed of sand merely and sometimes of minute fragments of shells, built very prettily into a mosaic work of fine white scales and grains of grey sand; many elytra of beetles were in the peat, retaining the same lustrous colours they had when alive. Also an extraordinary number of some purplish-brown or black bladder-like bags, which I supposed to be egg cases; also cocoon-shaped cases of some clear chitine-like substance which I also took to be egg cases. In the Bank Street peat a few small bones and teeth occurred, of which Mr Simpson, assistant to Professor Sir William Turner, has undertaken to give a description and list.

Of the superficial extent of this ancient lake we cannot fix the precise limits. We only know that from a little east of the station it extended westward in the line of the railway to about half-way between the station bridge and the bridge under the Kilconquhar road, and in the line of the High Street, from its junction with the Harbour Road, westward as far as Bank Street. How far it stretched north of the railway we do not know. But from recent exposures observed by Mr Affleck—one at Wadslea Farm, about one hundred yards south of the station; one at Elie Lodge, overlooking the Toft; one at the south side of Elie Manse lawn, just above the terraced gardens that stretch to the beach—it probably extended southward beyond what is the present shore line. Of its depth we have more precise knowledge. Dr Brown gives the depth of the deposit of blown sand with the layers of shelly peat as from 20 to 30 feet in perpendicular depth. But as in the upper part he mentions only land shells as being found, it may be that it represented a time when the lake was silted up; while the lower half, in which sand and fresh-water shells occurred together, represent the time when the lake existed. Mr Wood gives the thickness of the bed with fresh-water shells as not less than 10 or 12 feet, which suggests that it was probably more. In the exposures from which the shelly peat was got that I have examined, none of them exhausted the thickness. At the foundation for the new crane at the station, 7 feet was cut into.

The time when this lake spread its waters over the ground on which Elie now stands, was, as Dr Brown says, "of considerable antiquity," and probably was, as he concludes, in the times of the raised beach of Largo Bay, the deposition of the shelly peat going on in the lake, while the great accumulation of sand and sea-shells went on in Largo Bay. This gives a very considerable antiquity indeed, and justifies the term "ancient" we have applied to it. Before the Roman invasion—perhaps even before the people whose lands the Romans invaded came and possessed these lands,—when the only dwellers by the shores of Fife and the Lothians were the simple folk whose implements of bone or stone were found alongside the Airthrey whale in the Carse of Stirling—at that time when the Firth of Forth extended as much beyond Alloa as Alloa is west of Elie,—we may safely conclude that the lake peat, with the land and fresh-water shells we now pick out of its débris, was deposited grain by grain and shell by shell from the waters of this ancient lake of Elie.

But ancient as this lake of the shelly loam may be, we have had in our investigations glimpses of a much larger and more ancient lake at Elie—the lake of the submerged forest. My errand to Elie at Christmas 1889 was to obtain specimens of the submerged forest beds to compare with other lake peat I had found in Midlothian, at Redhall and Hailes quarries, as detailed in "The Ancient Lakes of Edinburgh." As the submerged forest peat was said by Mr Wood and Dr Brown to be exposed on the shore immediately to the east of Elie pier, I sought it there first, but found it hidden by a palisade of old railway sleepers erected as a bulwark against the sea. I discovered it, however, on the west side of the road to the harbour, at the north-east angle of Elie Bay, as mentioned by Mr Wood, and took a goodly sample of it for examination. On washing it I found almost nothing like what I got from other lake peats, and, most emphatically, none of the shells or other remains of animal life so rife in the later lake of Elie. The peat was hard, compact, almost rock-like, consisting of vegetable mud, with much driftwood in the shape of sticks, several inches in length and about one inch in diameter, rounded at the ends, and generally stripped of the bark. There were a few hazel nuts crushed and broken, a few sprays of mosses, and a number of bog beans gnawed by some small rodent for the sake of the kernels. I need not say that this was a great disappointment; but to give the submerged forest a further and a better chance, I got a fisherman, Mr Anderson of Liberty Place, Elie, to send me a bagful from Largo Bay near low-water mark, where he had often seen it while dredging for bait. On examination I found it identical with that from the north-east angle of Elie Bay. A hard, compact vegetable mud, with less driftwood in it, but a few more gnawed bog beans and better preserved sprigs of mosses. So ended, for the time being, my hope of getting something good from the submerged forest peat to match the lake peats of the Lothians. This failure is apparently due to the pureness of the peat, there being in it neither clay, nor silt, nor sand to modify or arrest that process of decay called eremacausis, by which all susceptible vegetable substances subjected to it turns eventually into amorphous dust or mud, or what Mr Smith of Kilwinning calls "parrot-coal" peat, because the vegetable matter in either is now only grains of black dust. Mr Thomas Scott has suggested that this amorphous lake peat is probably confined to the centre of the lake, where the water was deepest and free from clayey muds; and that peat from shallower water, by the shores of the lake, would probably have preserved in it the tenderer seeds of plants, or the shells of Mollusca and Ostracoda.

But, though we have failed to elucidate, as I had hoped, the character of the lake of the submerged forest, the records we have of its date and of the vegetable remains which have escaped the metamorphosis of eremacausis, clearly prove that from Elie westward for several miles, perhaps as far as Leven, a lake existed, which is considered, by all who have studied it, to have been a fresh-water lake, bordered, or perhaps preceded, by a forest.

In the first notice of this lake, published by Professor Fleming (Brande's *Journ. of Science*, 2nd series, vi., p. 21), he describes trunks of trees standing rooted in the soil beneath, but the only animal remains he found were those of certain sea creatures, that had taken up their abode in it after submergence in the sea. Dr Brown, in his paper "On the Shell Clay of Elie" (*Trans. Roy. Soc. Edin.*, xxiv., p. 617), records its occurrence in the section exposed in the railway cutting near Elie station, and on the shore, east of Elie pier, and next describes its appearance as a great peaty mass in Largo Bay, 4 feet in thickness, in which hazel and willow, and especially hazel nuts, were found, also other seeds, mosses, and especially abundant remains of *Arundo phragmitis*, adds that it sweeps for miles round Largo Bay, passing out at low water-mark, and considers it to have represented a land surface when Britain stood so high above the water as to be connected with the Continent. Mr Robert Howie, in Ballingal's "Shores of Fife," p. 147, gives the names of fifteen species of mosses which he had "collected from the vegetable drift of Largo Bay, the drowned valley of the traditional wood of the Forth;" and adds, "many of the specimens which grew under widely different conditions, were found drifted together in broken fragments."

Mr Wood ("East Neuk of Fife," 2nd ed., p. 488) records that on sinking a well on the south side of High Street, Elie, opposite the churchyard, a bed was found beneath 12 feet of blown sand, and resting on blue clay with "branches of hazel and oak, and some hazel nuts." And further, "in digging the foundation of the wall which bounds the road to the harbour on the west side, vegetable remains of the same kind were found, but the branches were larger, with a greater proportion of oak."

In the paper by Mr Wood on the railway cutting already quoted, he says, "that all over the whole town of Elie, wherever excavations have been made to the blue clay, a stratum of peaty matter has been found immediately above it, full of branches of oak, birch, and hazel, and even many hazel nuts. These may," he adds, "be contemporaneous with the submerged forest of Largo Bay noticed by the late Professor Fleming." To this I may add, that I have been assured by Mr Affleck and others, that this bed of peat with driftwood has been exposed during late years in excavations, such as noted by Mr Wood.[1]

These details concerning the earlier lake of Elie give a more complete idea of the remarkable series of deposits which represent the events which have taken place in that neighbourhood, from the times and climate of the Glacial period to nearly the present time. Of the Arctic shell clay Dr Brown's descriptions and lists of shells give an exceedingly good idea of the conditions that obtained on the east side of Scotland during the latter days of the Glacial period. Mr A. Bell's papers (p. 22) on the accumulation of sand and shells in Largo Bay, with the copious lists accompanying them, give a very accurate idea of the conditions prevailing in the sea of Elie during the Raised Beach period.

I trust that the facts stated in Mr Thomas Scott's preliminary note, and in the present paper, but especially in the lists of the Mollusca and Ostracoda by Mr Andrew Scott, give a good idea, as far as lake deposits can, of the land conditions of the same period.

List of Plants from the Ancient Lake of Elie, by Mr Clement Reid, F.L.S., of the Geological Survey of England.

Ranunculus aquatilis, Linn.
,, *Flammula*, Linn.
,, *repens*, Linn.
Viola?
Lychnis alba, Mill.
,, *diurna?* Sibth.
Stellaria media, Cyr.
Linum.
Rubus Idæus, Linn.
Potentilla Tormentilla, Neck.
Hydrocotyle vulgaris, Linn.
Æthusa Cynapium, Linn.
Valeriana officinalis, Linn.
Cnicus lanceolatus, Hoffm.
Menyanthes trifoliata, Linn.
Ajuga reptans, Linn.

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[1] *Note by Mr Affleck.*—"The driftwood I found in Bank Street twelve years ago was of goodly size, one in particular being an oak tree—black and hard like ebony—genuine bog oak. The trees were all lying north and south."

Atriplex patula, Linn.
Polygonum Persicaria, Linn.
Iris Pseudacorus, Linn.
Potamogeton.
Carex, several species.
Phragmites?
Chara.

List of Bones and Teeth from the Ancient Lake of Elie, by Mr James Simpson, Anatomical Museum, Edinburgh.

Humeral end of scapula of a rabbit (*Lepus cuniculus*).
Vertebræ of a small fish.
Molar tooth of the upper jaw of a sheep (*ovis aries*).
Two molar teeth of the upper jaw of a sheep (*ovis aries*). Crowns much worn.

PART II.

By Andrew Scott, Esq.

The following are the lists of the various species observed in the four deposits, described by Mr Bennie, who picked out the shells and assorted them, as far as he could, and then forwarded his collections to me, so that the work of looking over and naming them was a comparatively simple matter, when compared with the washing and examination of the material.

To enable a comparison to be made between the species from each locality, they are referred to separately, and a classified list, with short notes of all the species, is given at the end.

The nomenclature and classification followed is that adopted by the late Dr Gwyn Jeffreys in his "British Conchology."

The Bank Street Deposit.

Amongst the material from this ancient lake deposit, we have observed nineteen species of Mollusca, but two of these, viz., *Littorina littorea* and *Helcion pellucidum*, are marine, and are probably only waifs blown from the sea-shore, or conveyed by some other agency to the deposit. Of the remaining seventeen species, five are aquatic, two marsh, and ten terrestrial.

LIST OF MOLLUSCA FROM BANK STREET.

Pisidium fontinale (Drap.). Common.
,, *pusillum* (Gmel.). Frequent.
Planorbis nautileus (Linn.). Frequent.
,, ,, var. *cristata*. Rare.
Physa hypnorum (Linn.). Common.
Limnæa peregra (Müll.). Frequent.
,, *truncatula* (Müll.). Common.
Arion sp. (?), calcareous granules. Frequent.
Limax sp. (?), internal shell. Frequent.
Succinea putris (Linn.). Common.
Zonites fulvus (Müll.). Frequent.
Helix nemoralis, Linn. Rare.
Helix (?) *concinna*, Jeff. Common.
,, *pulchella*, Müll. Frequent.
Pupa marginata, Drap. Rare.
Vertigo minutissima (Hartm.). Frequent.
Cochlicopa lubrica (Müll.). Common.
Carychium minimum, Müll. Very common.

Waifs from Sea-shore.
Helcion pellucidum (Linn.). One specimen.
Littorina littorea (Linn.). A few.

Seven species of Ostracoda were also observed in this deposit, of which the following is a list:—

Cypria ophthalmica (Jurine). Rare.
Cypris virens (Jurine). Rare.
Potamocypris fulva, Brady. Rare.
Candona candida (Müller). Rare.
Candona pubescens (Koch). Rare.
,, *kingsleii*, Brady and Robertson. Rare.
Ilyocypris gibba (Ramdohr). Rare.

THE HIGH STREET DEPOSIT.

The material from this deposit yielded twenty-five species of Mollusca—five aquatic, two marsh, and eighteen terrestrial. The following is the list:—

Pisidium fontinale (Drap.). Frequent.
Pisidium pusillum (Gmel.). Rare.
Planorbis nautileus (Linn.). Rare.
Physa hypnorum (Linn.). Frequent.
Limnæa peregra (Müll.). Rare.
,, *truncatula* (Müll.). Common.
Arion sp. (?), calcareous granules. Frequent.
Limax sp. (?), internal shells. Frequent.
Succinea putris (Linn.). Common.
Zonites cellarius (Müll.). Rare.
,, *alliarius* (Mill). Rare.
Zonites radiatulus (Ald.). Frequent.
,, *fulvus* (Müll.). Frequent.
Helix nemoralis, Linn. Rare.
,, (?) *concinna*, Jeff. Common.
,, *pulchella*, Müll. Frequent.
,, *pygmæa*, Drap. Rare.
Pupa marginata, Drap. Rare.
Vertigo antivertigo (Drap.). Frequent.
,, *pygmæa* (Drap.). Common.
,, *substriata* (Jeff.). Frequent.
,, *angustior*, Jeff. Frequent.
,, *edentula* (Drap.). Rare.
Cochlicopa lubrica (Müll.). Common.
Carychium minimum, Müll. Very common.

Two species of Ostracoda were obtained in this deposit—

Scottia browniana (Jones). Rare.
Erpetocypris reptans (Baird). Rare.

THE CRANE PEAT DEPOSIT.

In this deposit we observed twenty-one species of Mollusca —five aquatic, two marsh, and fourteen terrestrial. The following is the list:—

Pisidium fontinale (Drap.). Common.
,, *pusillum* (Gmel.). Frequent.
,, *roseum*, Scholtz. Rare.
Planorbis spirorbis, Müll. Rare.
,, *contortus* (Linn.). Rare.
Limnæa truncatula (Müll.). Frequent.
Limax sp. (?), internal shells. Frequent.
Succinea putris (Linn.). Common.
Zonites aliarius (Müll.). Rare.
,, *radiatulus* (Ald.). Frequent.
Zonites crystallinus (Müll.). Rare.
,, *fulvus* (Müll.). Frequent.
Helix (?) *concinna*, Jeff. Frequent.
,, *pulchella*, Müll. Frequent.
Pupa marginata, Drap. Rare.
Vertigo antivertigo (Drap.). Frequent.
,, *pygmæa* (Drap.). Common.
,, *substriata* (Jeff.). Frequent.
,, *minutissima* (Hartm.). Rare.
Cochlicopa lubrica (Müll.). Common.
Carychium minimum, Müll. Very common.

HARBOUR ROAD DEPOSIT.

We obtained eighteen species of Mollusca from this deposit—one aquatic, two marsh, and fifteen terrestrial. The following is the list:—

Pisidium pusillum (Gmel.). Frequent.
Limnæa truncatula (Müll.). Common.
Arion sp. (?), calcareous granules. A few.
Limax sp. (?), internal shells. A few.
Succinea putris (Linn.). Common.
Zonites radiatulus (Ald.). Frequent.
,, *fulvus* (Müll.). Common.
Helix nemoralis, Linn. Rare.
Helix (?) *concinna*, Jeff. Common.
,, *pulchella*, Müll. Frequent.
Pupa marginata, Drap. Rare.
Vertigo antivertigo (Drap.). Frequent.
,, *pygmæa* (Drap.). Common.
,, *substriata* (Jeff.). Frequent.
,, *angustior*, Jeff. Frequent.
,, *minutissima* (Hartm.). Rare.
Cochlicopa lubrica (Müll.). Common.
Carychium minimum, Müll. Very common.

The following list includes all the species of Mollusca observed in the four deposits.

AQUATIC.

Class CONCHIFERA.

Order LAMELLIBRANCHIATA.

Family SPHÆRIIDÆ.

Pisidium fontinale (Draparnaud).

Pisidium, C. Pfeiffer

Cyclas fontinalis, Drap., Hist. Moll., 130, pl. x., figs. 8-12.
Pisidium henslowianum (var. without appendages), Jenyns, Ann. Nat. Hist., Aug. 1858, p. 104.
,, *fontinale*, Jeffreys, Brit. Conchology, vol. i., p. 20; vol. v., pl. i. (supplementary), fig. 6.
,, ,, Roebuck, Census of Scottish Land and Fresh-Water Mollusca, in Proceedings of the Royal Physical Society, 1889-90, p. 495.

This species was obtained in the material from three of the deposits mentioned in the preceding lists, the only deposit in which it was not observed was that exposed on the Harbour Road. It also occurred in some of the deposits described in the paper on "The Ancient Lakes of Edinburgh."[1]

As a living species, *Pisidium fontinale* appears to be widely distributed over Scotland. It is recorded from sixteen counties in the "Census," and we have it from some other localities on the west coast, besides that already recorded therein.

Pisidium pusillum (Gmelin).

Tellina pusilla, Gmel., Syst. Nat., p. 3231.
Pisidium pusillum, F. and H., vol. ii., p. 123, pl. xxxvii., fig. 10, and animal pl. O, fig. 9.
,, ,, Jeff., *op. cit.*, vol. i., p. 23; vol. v., pl. 1 (suppl.), fig. 7.
,, ,, Roebuck, *op. cit.*, p. 496.

This species appears to be of more frequent occurrence in the lake deposits than the last, and we obtained it in all the localities mentioned in these notes, as well as in some of the deposits described in previous papers.

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[1] Proc. Roy. Phys. Soc. Edin., vol. x., part i., pp. 126-154 (1889).

In its living condition, it is a widely distributed species, being probably the most common one of the genus.

Pisidium roseum (Scholtz).

Pisidium roseum, Scholtz, Schlesien's L.-und W. Moll., p. 140.
,, ,, Jeff., Ann. Nat. Hist., ser. 3, vol. iii., p. 38, pl. ii., fig. 3.
,, ,, Jeff., *op. cit.*, vol. i., p. 26; vol. v., pl. 1 (suppl.), fig. 9.
,, ,, Roebuck, *op. cit.*, p. 485.

This species was observed in only one of the deposits referred to here, viz., the Crane Peat, and does not appear to have occurred in any of the "Ancient Lake" deposits already referred to.

It is recorded as recent in the "Census" from ten counties.

CLASS GASTEROPODA.

Order PULMONOBRANCHIATA.

Family LIMNÆIDÆ.

norbis,
ettard.

Planorbis nautileus (Linné).

Turbo nautileus, Linn., Syst. Nat., ed. xii., p. 1241.
Planorbis nautileus, F. and H., vol. iv., p. 152, pl. cxxvi., figs. 6, 7.
,, ,, Jeff., *op. cit.*, vol. i., p. 82; vol. v., pl. v. (supp^l.), fig. 3.
,, ,, Roebuck, *op. cit.*, p. 485.

We observed this species in two of the deposits here described, viz., the Bank Street and High Street. It was also obtained in three of the deposits described in the paper on "Ancient Lakes of Edinburgh," as well as in "The Kirkland of Leven" deposit referred to in the *Proceedings* for 1889-90, p. 337.

The variety *cristata* was obtained in the material from the Bank Street deposit only.

Planorbis nautileus, including the variety *cristata*, appears
tribution, as a living species, in Scotland,

being recorded from thirteen different counties in the "Census."

Planorbis spirorbis (Müller).

Planorbis spirorbis, Müll., Verm. Hist., pt. ii., p. 161.
" " F. and H., vol. iv., p. 159, pl. cxxvii., figs. 9, 10.
" " Jeff., *op. cit.*, vol. i., p. 87; vol. v., pl. v. (suppl.), fig. 6.
" " Roebuck, *op. cit.*, p. 486.

This *Planorbis* occurred in only one of the deposits here described, viz., "The Crane Peat," and does not appear to have been observed in any of the Ancient Lake deposits already referred to.

As a living species it is widely distributed, and is recorded from thirteen counties in the "Census."

Planorbis contortus (Linné).

Helix contorta, Linn., Syst. Nat., ed. xii., p. 1244.
Planorbis contortus, F. and H., vol. iv., p. 160, pl. cxxvi., fig. 3.
" " Jeff., *op. cit.*, vol. i., p. 94; vol. v., pl. vi. (suppl.), fig. 4.
" " Roebuck, *op. cit.*, p. 487.

In the same deposit as the last. This species has already been recorded from Elie in the *Proceedings* for 1889-90. The deposit described in that paper probably belongs to the same Ancient Lake.

It is recorded as recent in the "Census" from sixteen counties.

Physa, Lamarck.

Physa hypnorum (Linné).

Bulla hypnorum, Linn., Syst. Nat., ed. xii., p. 1182.
Physa hypnorum, F. and H., vol. iv., p. 143, pl. cxxii., figs. 6, 7.
" " Jeff., *op. cit.*, vol. i., p. 26; vol. v., pl. vi. (suppl.), fig. 5.
" " Roebuck, *op. cit.*, p. 488.

This species was observed in material from two of the deposits described in this paper, viz., Bank Street and High Street. *Physa hypnorum* does not appear to have been previously recorded as a fossil for Scotland, and its occurrence in the Elie Ancient Lake deposit is interesting, as it indicates that the species has been a native of Scotland for a considerable period.

This *Physa* is only known to occur, as yet, in four counties —one of the localities being Dunbar, where it is found in large numbers in the old bleachfield, a short distance west from the Castle.

Limnæa peregra (Müller).

Buccinum peregrum, Müll., Verm. Hist., pt. ii., p. 130.
Limnæus pereger, F. and H., vol. iv., p. 168, pl. cxxiii., figs. 3, 7.
Limnæa peregra, Jeff., *op. cit.*, vol. i., p. 104; vol. v., pl. vii. (suppl.), fig. 3.
" " Roebuck, *op. cit.*, p. 489.

We have observed this species in two of the deposits described here, viz., Bank Street and High Street. It was obtained in almost all the deposits described in the previous papers on the Ancient Lakes.

As a living species, *Limnæa peregra* is widely distributed throughout the counties of Scotland.

Limnæa truncatula (Müller).

Buccinum truncatulum, Müll., Verm. Hist., pt. ii., p. 130.
Limnæus truncatulus, F. and H., vol. iv., p. 177, pl. cxxiv., fig. 3.
Limnæa truncatula, Jeff., *op. cit.*, vol. i., p. 115; vol. v., pl. vii. (suppl.), fig. 7.
" " Roebuck, *op. cit.*, p. 492.

This species occurred in all the four deposits referred to in these notes. It appears to have been observed in only one of the deposits described in the paper on "The Ancient Lakes of Edinburgh."

In its living state, the distribution of this species is almost as extensive as the last, and is recorded from twenty-five counties in the "Census." *Limnæa truncatula* is almost amphibious, and we have more frequently found it in slightly damp places, than in lochs or ponds; we have also occasionally found *Pisidia* under similar conditions.

TERRESTRIAL.

Family LIMACIDÆ.

Arion sp. ?

Arion,
Férussac.

We frequently find the calcareous grains that go to make up the internal shell of these slugs, in the ancient lake deposits, but there does not appear to be any marked difference between the shell-granules of the various species to enable one species to be identified from another with any great certainty.

Limax sp. ?

Limax,
Linné.

The shells or *Limacellæ* of some species of *Limax* are of frequent occurrence in the deposits, but it is difficult to determine, with any degree of certainty, to what species they may belong, as these shells, which are internal, and are usually much softer than the external shells of ordinary snails, undergo change of appearance more rapidly, and are also more liable to erosion, caused principally by the presence of carbonic acid, arising from the decaying vegetable matter of the old lakes.

Family HELICIDÆ.

Succinea putris, (Linné).

Succinea,
Draparna

Helix putris, Linn., Syst. Nat., ed. xii., p. 1249.
Succinea putris, F. and H., vol. iv., p. 132, pl. cxxxi., figs. 4, 5.
,, ,, Jeff., *op. cit.*, vol. i., p. 51; vol. v., pl. viii. (suppl.), fig. 4.
,, ,, Roebuck, *op. cit.*, p. 450.

This species was observed in all the deposits described in this paper; it is also recorded from the "Kirkland Marl," but does not appear to have been noticed in any of the deposits described in the paper on "The Ancient Lakes of Edinburgh;" the absence of this and several other species from the deposits described in that paper may be due to the small quantity of material that was available for examination. From first to last several hundredweights of the Elie deposits have passed through Mr Bennie's hands.

In its living state this species is of frequent occurrence, and is recorded from sixteen counties in the "Census."

Zonites cellarius (Müller).

Helix cellaria, Müll., Verm. Hist., pt. ii., p. 38.
Zonites cellarius, F. and H., vol. iv., p. 33, pl. cxx., figs. 1-3; and animal, pl. h. h. h., fig. 3.
,, ,, Jeff., *op. cit.*, vol. i., p. 159; vol. v., pl. ix., fig. 1.
,, ,, Roebuck, *op. cit.*, p. 453.

This species was obtained only from the material collected at the High Street, Elie, and does not appear to have been observed in any of the other deposits already described.

As a living species it is generally distributed throughout Scotland, and is recorded from thirty-four counties in the "Census."

Zonites alliarius (Miller).

Helix alliaria, Müll., in Ann. Phil., New Ser., vol. iii., p. 379.
Zonites alliarius, F. and H., vol. iv., p. 34, pl. cxx., figs. 5, 6.
,, ,, Jeff., *op. cit.*, vol. i., p. 161; vol. v., pl. ix., fig. 2.
,, ,, Roebuck, *op. cit.*, p. 454.

Zonites alliarius was observed in the material from only two of the deposits referred to in this paper, viz., the High Street and Crane Peat. This species does not appear to have been obtained in any of the previously described deposits.

From the "Census" it will be seen that this species is like the last, widely distributed in Scotland, being recorded from thirty-five counties.

Zonites radiatulus (Alder).

Helix radiatula, Ald., Cat. Northumb. Moll., p. 13.
Zonites radiatulus, F. and H., vol. iv., p. 38, pl. cxxi., fig. 1.
,, ,, Jeff., *op. cit.*, vol. i., p. 166; vol. v., pl. ix., fig. 5.
,, ,, Roebuck, *op. cit.*, p. 458.

This species occurred in three of the deposits described in this paper; the only one in which it was not observed being the Bank Street deposit. *Zonites radiatulus* does not seem to have been obtained in any of the other ancient lake deposits.

In its living state this species appears to be as widely distributed as the last, although it has not been recorded from so many localities; it is authenticated from sixteen counties.

Zonites crystallinus (Müller).

Helix crystallina, Müll., Verm. Hist., pt. ii., p. 23.
Zonites crystallinus, F. and H., vol. iv., p. 41, pl. cxxii., figs. 1, 2.
" " Jeff., *op. cit.*, vol. i., p. 170; vol. v., pl. x., fig. 3.
" " Roebuck, *op. cit.*, p. 459.

We observed this species in only one of the deposits described in this paper, viz., the Crane Peat. *Zonites crystallinus* does not appear to have been recorded for any of the deposits already described.

This species, in its living state, has a distribution somewhat similar to the previous two, and is recorded from thirty different counties.

Zonites fulvus (Müller).

Helix fulva, Müll., Verm. Hist., pt. ii., p. 56.
" " F. and H., vol. iv., p. 75, pl. cxviii., figs. 8, 9.
Zonites fulvus, Jeff., *op. cit.*, vol. i., p. 171; vol. v., pl. x., fig. 4.
" " Roebuck, *op. cit.*, p. 460.

This species occurred in all the four deposits mentioned in this paper, and also in the Kirkland and Elie deposits previously described.

As a living species, *Zonites fulvus* is widely distributed in Scotland, and is recorded from twenty-six counties.

Helix,
Linné.

Helix nemoralis (Linné).

Helix nemoralis, Linn., Syst. Nat., ed. xii., p. 1247.
" " F. and H., vol. iv., p. 53, pl. cxv., figs. 1-4.
" " Jeff., *op. cit.*, vol. i., p. 185; vol. v., pl. xi., fig. 3*a*.
" " Roebuck, *op. cit.*, p. 462.

A few specimens only of this *Helix* were obtained in the material from three of the deposits described in this paper, the only deposit in which it was not observed being the Crane Peat. This is a species that does not appear to have been obtained in any of the ancient lake deposits already described, but has been observed in the Marine Post-Tertiary deposits of the Clyde, etc.

In its living state, it is probably one of the most widely distributed of the *Helices* in Scotland, and is authenticated from twenty-six counties in the "Census."

Helix ? concinna (Jeffreys).

Helix concinna, Jeff., in Linn. Trans., vol. xvi., p. 336.
,, *hispida*, var. *concinna*, F. and H., vol. iv., p. 70, pl. cxviii., figs. 2, 3.
,, *concinna*, Jeff., *op. cit.*, vol. i., p. 196; vol. v., pl. xii., fig. 2.
,, ,, Roebuck, *op. cit.*, p. 467.

Shells apparently belonging to this species were of frequent occurrence in all the deposits at Elie described in this paper.

Helix concinna is recorded in the "Census" from fourteen counties.

Helix pygmæa (Draparnaud).

Helix pygmæa, Drap., Tabl., p. 93, and Hist., p. 114, pl. viii., figs. 8-10.
,, ,, F. and H., vol. iv., p. 83, pl. cxxi., figs. 9, 10.
,, ,, Jeff., *op. cit.*, vol. i., p. 223; vol. v., pl. xiii., fig. 7.
,, ,, Roebuck, *op. cit.*, p. 472.

Only a few specimens of this species were observed in the material from the High Street deposit; owing to its minute size it is difficult to observe, and this may account for its not having been previously recorded from the ancient lake deposits.

As a living species it is widely distributed but not very common. It is recorded from seventeen counties in the "Census."

Helix pulchella, Müller.

Helix pulchella, Müll., Verm. Hist., pt. ii., p. 30.
,, ,, F. and H., vol. iv., p. 78, pl. cxix., figs. 9, 10.
,, ,, Jeff., *op. cit.*, vol. i., p. 224; vol. v., pl. xiv., fig. 1.
,, ,, Roebuck, *op. cit.*, p. 473.

This species was obtained in all the deposits at Elie and in the Kirkland marl.

In its living state this species is apparently almost wholly restricted to the counties on the east coast of Scotland, only three western counties being given for it in the "Census."

Pupa marginata, Draparnaud.

Pupa,
Lamarc

Pupa marginata, Drap., Tabl. Moll., p. 58, and Hist. Moll., p. 62, pl. iii., figs. 36-38.
,, *muscorum,* F. and H., vol. iv., p. 97, pl. cxxix., figs. 8, 9.
,, *marginata,* Jeff., *op. cit.*, vol. i., p. 249; vol. v., pl. xv., fig. 4.
,, ,, Roebuck, *op. cit.*, p. 476.

Specimens of this *Pupa* were obtained in all the Elie deposits, but does not appear to have been observed in any of the other ancient lake deposits previously described, with the exception of the Elie one described in preliminary notes. We have specimens of this *Pupa* from a raised sea-beach at Millport, Cumbrae, collected in 1881.

As a living species this *Pupa* appears to be confined to the maritime counties of Scotland, no record from any inland towns being given in the "Census."

Vertigo antivertigo (Draparnaud).

Vertigo
Müller.

Pupa antivertigo, Drap., Tabl. Moll., p. 57, and Hist. Moll., p. 60, pl. iii., figs. 32, 33.
,, ,, F. and H., vol. iv., p. 109, pl. cxxx., fig. 7.
Vertigo antivertigo, Jeff., *op. cit.*, vol. i., p. 253; vol. v., pl. xv. fig. 5.
,, ,, Roebuck, *op. cit.*, p. 477.
,, ,, Scott, T., Some Notes on the Scottish species of the Molluscan Genus Vertigo, in *Scottish Naturalist* for April 1891.

This species was observed in the material from three of the deposits described in this paper, the only deposit in which it was not observed being the Bank Street one.

In its living state it is usually found in damp places, in the vicinity of ponds. It is recorded from six counties in the "Census." Those range from north to south and from east to west.

Vertigo pygmæa (Draparnaud).

Pupa pygmæa, Drap., Hist. Moll., p. 6, pl. iii., figs. 30, 31.
,, ,, F. and H., vol. iv., p. 106, pl. cxxx., figs. 4-6.
Vertigo pygmæa, Jeff., *op. cit.*, vol. i., p. 257; vol. v., pl. xv., fig. 7.
,, ,, Roebuck, *op. cit.*, p. 477.
,, ,, Scott, T., *op. cit.*

This is a much more common species, both recent and fossil, than the last, and is widely distributed.

Vertigo substriata (Jeffreys).

Alæa substriata, Jeff., in Linn. Trans., vol. xvi., p. 515.
Pupa substriata, F. and H., vol. iv., p. 108, pl. cxxx., fig. 3.
Vertigo substriata, Jeff., *op. cit.*, vol. i., p. 216; vol. v., pl. xvi., fig. 2.
,, ,, Roebuck, *op. cit.*, p. 477.
,, ,, Scott, T., *op. cit.*

This species, though of not so frequent occurrence, was observed in the same deposits as the last.

As a living shell this *Vertigo* is recorded in the "Census" from three counties only. In the *Scottish Naturalist* for April 1891 three more localities are given, and to these may now be added another, taken from "Brit. Conch.," viz., East Lothian. Jeffreys in "British Conchology," vol. i., p. 262, mentions that "Dr Johnston found this species in East Lothian at a height of 1200 feet," so that Dr White's statement as to its distribution may after all be correct.

Vertigo angustior, Jeffreys.

Vertigo angustior, Jeff., in Linn. Trans., vol. xvi., p. 361.
Pupa venetzia, F. and H., vol. iv., p. 112, pl. cxxx., fig. 9.
Vertigo angustior, Jeff., *op. cit.*, vol. i., p. 265; vol. v., pl. xvi., fig. 4.
,, ,, Roebuck, *op. cit.*, p. 478.
,, ,, Scott, T., *op. cit.*

We observed specimens of the *Vertigo* in the material from two of the deposits described here, viz., the High Street and the Harbour Road. Many specimens were obtained from each locality.

In its living condition this species appears to be very rare in Scotland, only one record being given in the "Census" for it, viz., Strathbrora, Sutherland, E.

Vertigo edentula (Draparnaud).

Pupa edentula, Drap., Hist. Moll., p. 52, pl. iii., figs. 28, 29.
„ „ F. and H., vol. iv., p. 103, pl. cxxx., fig. 1.
Vertigo edentula, Jeff., *op. cit.*, vol. i., p. 268; vol. v., pl. xvi., fig. 6.
„ „ Roebuck, *op. cit.*, p. 478.
„ „ Scott, T., *op. cit.*

Only one or two specimens of this species were obtained in the material from the deposit at the High Street. This is in all likelihood part of the same deposit referred to in the *Scottish Naturalist* for April 1891.

As a living species this *Vertigo* is widely distributed, being recorded from eighteen counties in the "Census."

Vertigo minutissima (Hartmann).

Pupa minutissima, Hartm., in New Alp., vol. i., p. 222, pl. ii., fig. 5.
„ „ F. and H., vol. iv., p. 104, pl. cxxx., fig. 2.
Vertigo minutissima, Jeff., *op. cit.*, vol. i., p. 270; vol. v., pl. xvi., fig. 5.
„ „ Roebuck, *op. cit.*, p. 478.
„ „ Scott, T., *op. cit.*

This species was observed in three out of the four deposits examined, the only one in which we failed to find it being the High Street deposit.

There is nothing further to add to the note on this species which appeared in the *Scottish Naturalist* for April 1891.

Cochlicopa lubrica (Müller).

Helix lubrica, Mull., Verm. Hist., pl. ii., p. 104.
Zua lubrica, F. and H., vol. iv., p. 125, pl. cxxv., fig. 8, and animal pl. g. g. g., fig. 5.
Cochlicopa lubrica, Jeff., *op. cit.*, vol. i., p. 292; vol. v., pl. xviii., fig. 2.
Zua lubrica, Roebuck, *op. cit.*, p. 481.

This species occurred in all the four deposits here described, but does not appear to have been recorded from any of the ancient lake deposits previously described, except in connection with the deposit at Elie referred to in "Preliminary Notes." It was excluded from the list of shells observed in the material from that deposit, owing to there being some doubt as to whether it really belonged to that deposit or not; but we have now no hesitation in including *Cochlicopa lubrica* in the list, along with the other shells from the Elie deposits.

As a living shell, this species has a wide distribution, and appears to be common in all the localities where it is found. It is recorded from thirty-six counties in the "Census."

Family CARYCHIIDÆ.

chium,
er.

Carychium minimum, Müller.

Carychium minimum, Müll., Verm. Hist., pt. ii., p. 125.
" " F. and H., vol. iv., p. 198, pl. cxxv., fig. 6.
" " Jeff., *op. cit.*, vol. i., p. 300; vol. v., pl. xviii., fig. 4.
Carychium carychium, Roebuck, *op. cit.*, p. 482.

This species occurred in large numbers in all the four deposits at Elie, some of the specimens being much longer than usual.

As a living species this shell is widely distributed. It is recorded from twenty-one counties in the "Census of Scottish Mollusca."

In the "Census," Montagu's name *Carychium carychium* is adopted for this shell, but no reason is given for doing so; and as Müller described the species under the name used here, nearly thirty years before Montagu, there can be no question as to its priority over that of Montagu's. In Brown's "Recent Conchology of Great Britain and Ireland," 2nd edition, published 1845, Müller's name is used for this shell, and as shown by the synonymy given here for the species, Forbes and Hanley, in their "History of British Mollusca and their Shells," published 1853, likewise used Montagu's name, as also did Jeffreys in his work.

XV. *Supplementary Observations on the Cubital Coverts of the Euornithes.* By J. G. Goodchild, Esq., H.M. Geol. Survey, F.G.S., F.Z.S., Member of the British Ornithologists Union.

(Read 21st December 1892.)

Shortly after the publication of my last communication to the Royal Physical Society,[1] dealing with the cubital coverts of birds in their relation to classification, Sir William Flower honoured me with a request for a set of wings to illustrate the chief points therein referred to, in order that they might be exhibited in the Index Collection at the Natural History Museum, South Kensington. This commission would not have been easy to execute, had not several fellow-workers in zoology interested themselves to obtain specimens in the flesh of the various birds whose wings were required for this purpose. Through their friendly co-operation I have thus been enabled to examine anew many species about whose wing style more or less uncertainty was felt, and have, further, had an opportunity for the first time of studying the wing style prevailing amongst several other birds, which I had not previously handled in the fresh state. In addition to the facts gathered in this manner, I have re-examined, and carefully drawn, the appearances presented by a large number of species in the living state, chiefly at the Zoological Gardens of London; and have, further, dissected the wings of a number of interesting forms of birds, which I have been enabled to do chiefly through the kind offices of Mr Beddard, the Prosector to the Zoological Society.

This re-survey of the subject has resulted in bringing to light several additional facts of interest; and, as might have been expected from the nature of the investigations, has led me to modify a few of the statements previously put forth by myself and other students of the subject. In the present communication it is proposed to summarise the facts so far as they are yet known.

In my original paper on the subject of Birds Wings,[2] the chief object aimed at was to record the external characteristics as they appeared in the living birds, and the paper was addressed to those who, like myself, were engaged in zoological art-work. For such a purpose it was not at all necessary to enter into any detail respecting the structural characters of the wings, or even to discuss the more important matter of the insertion of the feathers. Since that paper was read, the relationship of each group of feathers to the bony framework of the wing has received a considerable amount of attention from Dr Sclater, Dr Gadow, Professor Flower, Mr Wray, Mr Pycraft, and others; and I have myself by no means neglected the subject. The main features at present known may, therefore, advantageously be set forth here.

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[1] Proc. Roy. Phys. Soc., vol. x., pp. 317-333.

[2] Proc. Zool. Soc., April 1886.

Attention will be confined in this paper exclusively to the feathers that appear upon the outer face of a wing, as being those that are subject to the more interesting sets of variations. Regarded in connection with their insertion upon the fore-limb of a bird, the feathers may be primarily grouped into (1) those seated upon any part of the humerus; which will be herein referred to as the Postcubitals or Humerals. (2) Those originating upon any part of the forearm, or of the integuments connected therewith; these will be termed the Cubitals. (3) The feathers seated upon any part of the wing beyond the carpal end of the forearm, including those seated upon the carpus proper, as well as those originating upon the metacarpo-digital region; for these, collectively, the name Antecubitals will be used in this paper.

The Humerals present some interesting features, but it is not proposed to study these now. The Cubitals naturally group themselves into four sets, to which, for convenience of description, it is customary to add a fifth set. These are, counting from the flight feathers towards the front edge of the wing, (1) the Remiges, which call for no special remark at present; (2) the Major Coverts. The base of each remex is attached to the under side of the ulnar, and the Major Coverts, which theoretically correspond in number to the Remiges, form a single row, which is based nearly on the same level as their respective primaries, but a little on their humeral side. Their shafts are set somewhat obliquely, so that the tip of each Major Covert is carried beyond, or on to the distal side of, its corresponding remex. Inserted on the integument covering the side of the Cubitus are groups (2) and (3)—the Medians and the Minors, respectively. Each Median is attached a little above the point of insertion of its corresponding Major, and invariably also a little on its humeral side. The Medians form a single row, and are of special interest as being the chief seat of variation in the different groups of birds. The Minors comprehend a variable number of rows of feathers, which lie between the Medians and the fold of integument above the radius. The first row of Minors is seated a little above, and on the humeral side of, its respective Median and Major, in such a manner that a line joining the bases of any set of all three, passes obliquely across the wing. The disposition of the Cubital Coverts during life, would suggest that the Minors above the lowest row should be based in the same line as the three feathers just referred to; but the general disposition of the feathers lends some support to the generally received view, that the bases of the Minors are arranged in quincunx, or in zig-zag instead of in a straight line across the wing, as is the case with the insertions of the covert feathers there referred to.

The feathers seated on the loose fold of integument, or patagium, extending along the front edge of the forearm, are distinguished as the Marginals. In most birds they can be easily made out by the fact that when the patagium is flexed towards the under face of the wing the edges of the feathers seated on it are raised more or less, while those attached to the face of the forearm remain, in general, unmoved. The distinction between the Minors and the Marginals, however, is not in all cases easily determined.

In the Antecubital region of the wing a separation of the feathers into remiges, majors, medians, minors, and marginals is usually possible. But as the variations to which these are subject do not yet appear to have been thoroughly worked out, they will be passed over with only incidental notice on the present occasion.

In describing the details of arrangement of the feathers, it is convenient to make a departure from the old system of numbering of the feathers, and to count them outwards from the carpal joint. The 1st remex, therefore, of both the Cubital and the Antecubital region is that next the carpus, and from this the Cubitals are numbered in the direction of the humeral joint, while the Antecubitals are counted in the opposite direction. The same rule is adopted with their respective coverts. The 1st Antecubital Remex is generally very much reduced in size, or may even be absent entirely. Where it is present it was often regarded as a covert feather until Mr Pycraft pointed out its true nature.[1] Antecubital remiges 2, 3, 4, 5, 6, and 7 are seated in the metacarpals, 8 is situated on the 3rd digit, 9 and 10 on the 1st phalanx, 11 on the 2nd phalanx, and 12, distinguished as the Remicle, on the 3rd phalanx.[2] Passing to the cubitus, we find the feather usually regarded as the 1st cubital remex seated partly in many cases, and entirely seated in others, upon the *carpal bone.* Beyond the 1st the remaining remiges, in one section of the Euornithes, succeed each other uniformly and without any break, up to near the humeral joint. Here, in the birds whose forearm has been shortened within recent times, the terminal feathers are often soft, and more or less reduced in size, as if any reduction of the feathers consequent upon the shortening of the forearm had taken place gradually at the humeral end of the cubitus. That this is the correct view will be rendered highly probable by some details respecting the coverts to be given presently. In another section of birds, the continuity of the remiges is interrupted, and the " fifth " is either absent entirely, or else is, it appears to me, reduced to a small downy feather, which does duty as one of the *inner* coverts. Whether I am correct in this view or not is immaterial, as in either case the 5th cubital remex is functionally absent. Those birds in which the (reputed) 5th cubital remex is present are distinguished as quincubital, and those in which it is functionless are termed aquincubital. For the reasons given above, these terms are not exactly suitable; but as zoologists have generally adopted them, it is better to retain them as they are than to introduce unnecessary confusion by employing new names. In all birds soever, the remiges overlap distally, or in such a manner that the distal edge of each feather overlaps the proximal edge of the feather next distant from the vertebral axis, as they are viewed on the outer face of the wing.

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[1] Pycraft, Contribution to the Pterylography of Birds' Wings.

[2] See Sir William Flower's specimens at the Natural History Museum, upon which part of this description is based.

Turning now to the Cubital Majors, which are present in all the Euornithes, we find a remarkable feature, which was first made known many years ago by M. Gerbe. Whether the 5th c.r.[1] is present or is absent, its corresponding major covert is present invariably in all birds. Further, I have pointed out on more than one previous occasion, that in those wings in which the 5th c.r. is present the Majors form an uninterrupted series, shortening, or lengthening, gradually, from one end of the cubitus to the other. But where the 5th c.r. is absent an interruption of this uniformity becomes evident. The major coverts lengthen rapidly from the first to the fifth, which now becomes the longest of the Cubital Majors; while the sixth Major is often very considerably shortened, so as to appear to be not more than half the length of the exposed part of the feather preceding it. Moreover, when traced to its insertion, the seat of the feather is often at a higher level than that of the feathers on either side. The fifth Major is the longest, and the sixth one of the shortest, in all aquincubital birds, and the difference in length is so marked that it can easily be detected in the living bird, which thus bears on its wing a perfectly clear and certain indication of its aquincubitalism. In all birds of every known family, the Majors overlap distally, like the remiges. The overlap of the Medians, on the other hand, varies much from group to group, although it is, at the same time, constant for all birds presenting similar structural characteristics. To such an extent is this the case, that a mere glance at the arrangement, or style of imbrication, in the Medians, even in the case of a living bird, will suffice to show to what section of the Euornithes it belongs; and will even enable one, in the case of a bird whose anatomy is imperfectly known, to predicate with tolerable certainty what will prove to be the

[1] A convenient abbreviation for "Fifth Cubital Remex."

characteristics of its palatal structure, of its myology, of its visceral anatomy, or of its pterylosis. Like all other single characters, however, this particular one has less taxonomic value in certain cases than in others; but its claim to rank as a taxonomic feature of some importance now hardly admits of being called in question. The Medians and also the Minors participate in the faulting that accompanies aquincubitalism.

At first it appeared as if the variations in the style of wing coverts arising from the absence of the 5th c.r. might be trusted as a feature of taxonomic value, and in my earlier papers it was so treated. But recent investigations by Dr Sclater and others have shown that this view of its importance cannot be sustained. Whole groups of birds are, it is true, characterised by the "faulted" coverts, which mark the absence of the 5th c.r. It may be said, indeed, that the Euornithes may be divided into three sections, in accordance with this feature. The whole of the Trochili, Passeres, Coccyges, Crypturi, Hemipodes, and Gallinæ are characterised by the unfaulted cubital coverts which mark the quincubital birds. In the whole of another large group, comprising the Caprimulgi, Psittaci, Striges, Accipitres, Cathartæ, Serpentarii, Pandiones, Pernidæ, Herodiones, Anseres, Columbæ, Steganopodes, Tubinares, all the Gavio-grallæ (except one genus of Fulicariæ), including the Cranes, the Bustards, and the Sandgrouse, have the wing coverts faulted. On the other hand, while in the majority of the Pici, Coccyges, and Cypseli the wing coverts are unfaulted—the 5th c.r. being present—yet in many species of Picarian birds and Swifts, about whose close relationship to the normal forms there can be no doubt, the 5th c.r. is absent, and the coverts are faulted accordingly. Closely allied genera of Swifts as well as of Kingfishers may show these exceptional characteristics.

The one feature of this kind that does appear to be constant in allied groups of birds is the *direction* of overlap of the first twelve Medians and their accompanying Minors. In the Trochili, Trogones, Paradisiidæ, Coccyges, Musophagidæ, Caprimulgi, and some few other forms, the whole of the wing coverts—majors, medians, minors, and marginals—overlap distally. On the first five of these the 5th c.r. is present, and the coverts consequently unfaulted. In the Caprimulgi (or, at any rate, in *Caprimulgus* itself) the coverts are faulted and the 5th c.r. is absent. The wing style of the Goatsuckers is, in fact, the same as what that of the Cuckoos would be if aquincubital. The Swifts agree with the foregoing six groups in having a predominant distal overlap of the coverts; but, as before remarked, some forms are quincubital, while others lack the 5th c.r., and the wing style differs accordingly.

The normal Passeres have a style peculiar to themselves. In these the one row of Medians shows uninterrupted proximal overlap, and this is succeeded by a single row of Minors, which shows overlap in the reverse direction, so as to be hardly distinguishable from the Marginals. This style is characteristic of the whole of the Passeres excepting the Corvidæ. In the Crows, as I have pointed out on former occasions, the first six Medians overlap distally, the next three (or a variable, but small, number) overlap proximally, and the remainder show distal overlap. The difference between the wing style of the Corvidæ and that of the whole of the rest of the Passeres is much too pronounced to be entirely without significance. If one may judge by the wing style, the Corvidæ do not belong to the Passeres at all, but must form a group close outside, and not far removed from the Paradisiidæ, and with a relationship more distant with the Trogones.

To what I have already stated regarding the Trochili I have nothing further to add—their wing style is peculiar, and finds its nearest parallel in the next group.

The Cypseli present two styles, in accordance with the presence or the absence of the 5th c.r. They have one row of Medians showing distal overlap, and usually two rows of Minors arranged in the same manner as the Medians. The bases of the Marginals are marked off from those of the Minors by a tract devoid of feathers, so that the distinction that has been made between these two groups of feathers is fully justified in this case. Where the 5th c.r. is absent the coverts are faulted, giving rise to a very peculiar style of wing.

The Cuculi, Musophagi, and the Caprimulgi have essentially the same style of wing coverts as the Swifts, only in the present group the coverts are unfaulted in the two first, and are faulted in the last. This feature is very well seen in *Caprimulgus europæus.*

The normal Picarian style of wing agrees with the Passerine in regard to the overlap of the Medians, which form an uninterrupted series overlapping proximally. But the Minors in this group form rarely less than two rows (*Yunx* has only one), more often there are three, and, in some birds, more than three rows of Minors. All these agree with the Medians in showing proximal overlap. Some genera of Picarian birds are aquincubital, and in such cases there is practically nothing to distinguish the wing from that of the next section. *Yunx torquilla* has only one row of Minors, with proximal overlap, and its insertions are separated by a bare space from the line of attachment of the Marginals, as in the Swifts. The normal Picarian style is very marked, and easily enough recognised.

In the Gallinæ the wing style closely resembles that of the Picarians, but it differs from it in the increased number of rows of Minors, and also, in general, in the prominence assumed by the proximal third of the Medians and Minors, which are usually large in size, and show distal overlap. In the living birds this feature is so marked as to give to the Galline wing coverts the appearance of being imbricated distally over the whole surface. The Galline style prevails throughout the Alectoropod and Peristeropod sections, and is found with no modification I have yet been able to detect also in the Crypturi and the Hemipodii. The Turkeys have a wing style which is remarkable for the number of covert feathers which show proximal overlap.

Closely following the Gallinæ in wing style, but with the difference due to aquincubitalism, comes a large number of birds which have, at first sight, very little else than this feature in common. There is practically no difference, except in the number of Medians and Minors, showing proximal overlap between the Psittaci, Striges, Accipitres properly so called, Herodiones (Herons and Bitterns), Anseres, Steganopodes (Cormorants and Pelicans only), Fulicariæ (exclusive of *Heliornis*), Pygopodes, Colymbi, and the Guillemots. In the whole of these the 5th c.r. is functionally absent, and consequently the Majors, Medians, and Minors are, all alike, faulted over the place of the defunct remex. The first six Medians, and usually not less than three following, and their three or four rows of corresponding Minors, show proximal overlap. The *number* of feathers in each row appears to be directly related to the length of the cubitus. Where this is comparatively short, the abbreviation of the feathers takes place at the expense of such coverts as lie nearest to the cubito-humeral joint, and at the same time overlap *proximally*. In other words, as the forearm is shortened, in adaptation to changed modes of life, the covert feathers first to disappear are not those directly at the proximal end of the cubitus, but only such of them as show proximal overlap—those terminal feathers that show distal overlap apparently in all cases surviving the change, and advancing to a position nearer and nearer to the carpus. It is not easy to say why this should be so; but the facts seem to point to no other conclusion. Conversely, with increased length of forearm, the covert feathers added on come between those showing proximal overlap and those showing distal overlap, which invariably form the end of the series. This consideration will enable the reader to perceive the distinction between the Rails (exclusive of *Heliornis*), the Gallinules and Coots, the Grebes (whose wing style marks them as Diving Rails), and the Colymbidæ. Whether the ancestral form of the Landrail was Colymboid, or whether Colymbus is a marine Grebe, and, therefore, a Rail, whose structure has been adapted to a mode of life in the open sea, cannot be definitely stated. If I might hazard a guess, it would be to the effect that Colymbus is the nearest living representative of the ancestral form; that the Crakes represent one section of its descendants modified to a life inland; and that, possibly, the Grebes are reverting from the Ralline stage of modification to one more nearly resembling Colymbus. *Heliornis* appears to be a quincubital Rail, judging by a specimen lent to me by Mr Beddard. The relationship of the Guillemots to Colymbus I can only guess at; but the range of variety of wing style amongst the "Divers" suggests that they have arisen from several different stocks, of one of which the Plovers may be regarded as the modern representatives.

Some of the birds usually included in the Accipitres belong elsewhere, if their wing style affords any trustworthy indication of their affinities. The groups referred to are the Cathartæ, whose wings have the same style as those of *Leptoptilus; Gypaetus,* which may be a Palæarctic representative of the Cathartæ; *Serpentarius,* which, again, resembles the Storks in this respect; the Pandiones, whose wing style is peculiar to itself, but comes nearest to some of the Divers; and lastly, the Honey Buzzards (Pernidæ), whose wing style would place them not far from the Storks.

In all the birds just noticed, the first six Medians and their respective Minors overlap *proximally,* and the same mode of imbrication characterises a variable number of these covert feathers beyond the sixth. In all the birds remaining to be noticed the 5th c.r. is wanting, the coverts are faulted, and at least the first five Medians have a *distal* overlap. In the majority of the birds only three or four of the Medians, usually numbers 6, 7, and 8, are the only feathers belonging to this series that show proximal overlap. Usually the first eight or ten of the Minors overlap proximally, in some birds more than that number. As there is no new feature of special importance connected with these, they will be passed over with only a brief notice. As a central form, around which all the members of the group under notice may be placed, is *Charadrius,* well represented by the Golden Plover, whose wing is shown in fig. 18, pl. xv., vol. x., *Proceedings of the Royal Physical Society.* Near this stand the Cranes, Bustards, and Sandgrouse. The wing style of the last-named bird finds its nearest representative in the Plovers; it is certainly quite unlike the wing of any Galline bird. Near the Plovers also comes *Goura,* whose wing, figured No. 16 (*loc. cit.*), occupies an intermediate position between the Peristeropod Gallinæ and the Pluvialine birds. Next comes the normal Columbæ (fig. 17). With these commences a series in which the whole of the Medians show distal overlap. Near to the Plovers come the Gulls and Terns (fig. 20), together with the non-diving Petrels. Another line of modification of the Pluvialine pattern leads to the Phœnicopteridæ, Plataleidæ, Ciconiidæ, *Serpentarius*, *Tantalus*, and some few other birds.

Linked on to the last by the Skuas and the Fulmars, and at the end of the whole series, comes a certain number of birds whose wings show distal overlap over nearly their whole surface. These include the Cathartæ (fig. 22, *loc. cit.*), *Leptoptilus* (fig. 21, *loc. cit.*), *Fregata*, *Sula* (fig. 23, *loc. cit*), *Diomedea*, *Plotus* (fig. 24, *loc. cit.*), *Puffinus*, and the Tubinares in general.

In conclusion, I have to thank the following gentlemen for help rendered by the gift of specimens—Captain Davies, Skomer Island; Rev. H. A. Macpherson; Prof. D'Arcy Thompson; Messrs Robert Howard; J. C. Smith, Penrith; F. E. Beddard; Wm. Evans, Sec. Royal Physical Society; W. Eagle Clarke, Donald Knight, Frank Traill, and others.

PLATE I.

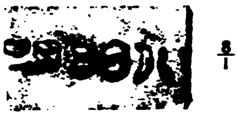
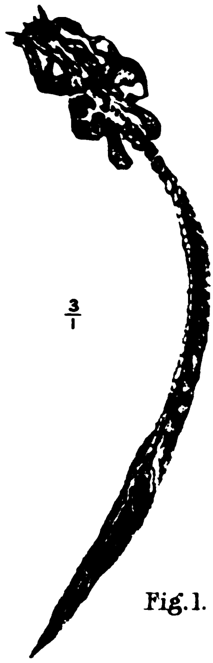


Fig. 3.



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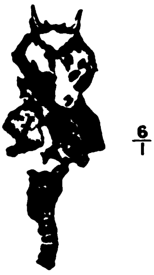

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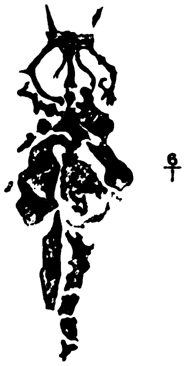

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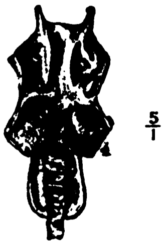


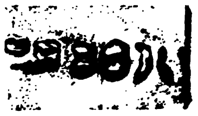
Fig. 2.

R. H. Traquair ad nat. del.   J. D. Bowie Lith.

PALÆOSPONDYLUS GUNNI *(Traquair.)*

PLATE I.

Vol. XII. *Royal Physical Society Edinburgh*



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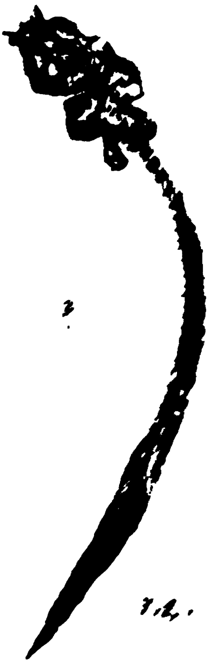

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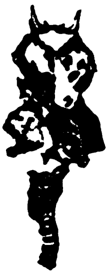

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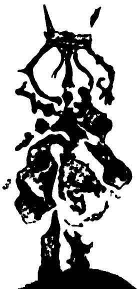

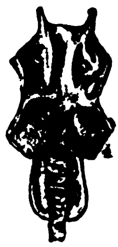

Fig. 2

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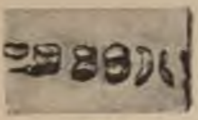
PLATE I.

Vol. XII. *Royal Physical Society, Edinburgh.*



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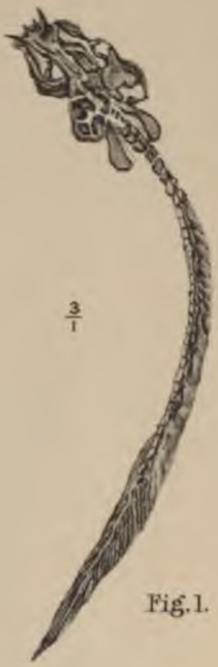
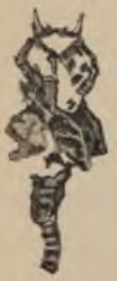


Fig. 1.



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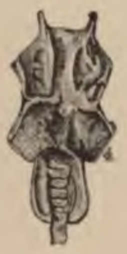


Fig. 2.

J.D. Bowie Litho.

DYLUS GUNNI *(Traquair.)*

PLATE I.

Vol. XII. *Royal Physical Society, Edinburgh.*

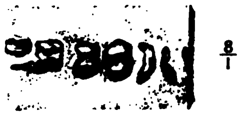


Fig. 3.

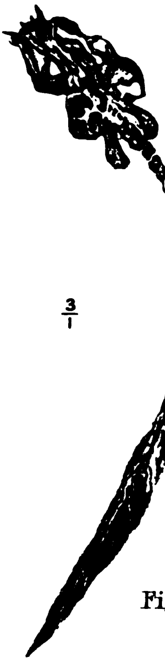
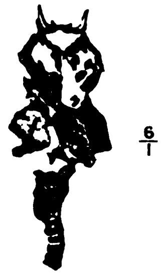


Fig. 1.



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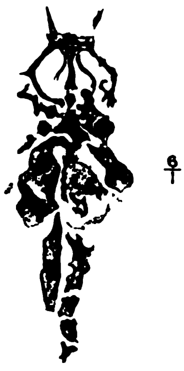

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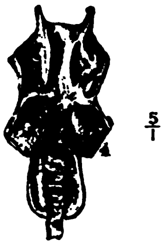
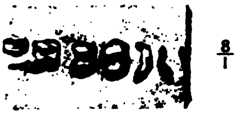


Fig. 2.

R. H. Traquair ad nat del. J D Bowie Lith.

PALÆOSPONDYLUS GUNNI (*Traquair.*)

PLATE I.



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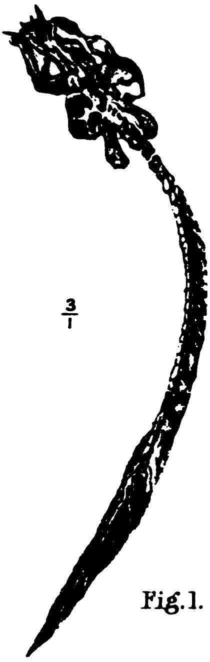
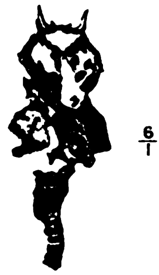


Fig. 1.



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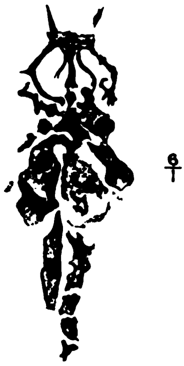

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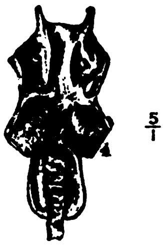


Fig. 2.

R. H. Traquair ad nat del. J. D. Bowie Lith.

PALÆOSPONDYLUS GUNNI (*Traquair.*)

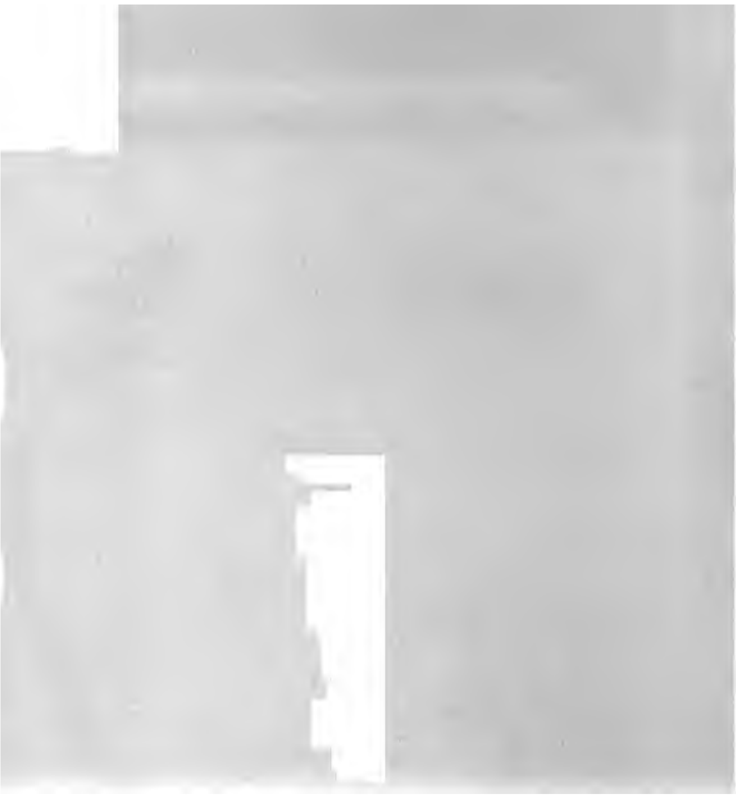
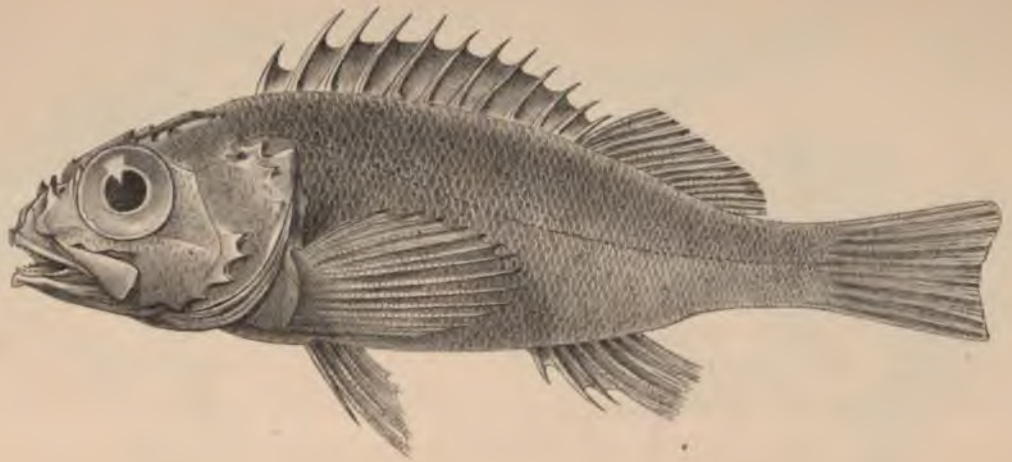


PLATE II

Vol. XII. Royal Physical Society, Edinburgh



Royal Physical Society, Edinburgh.

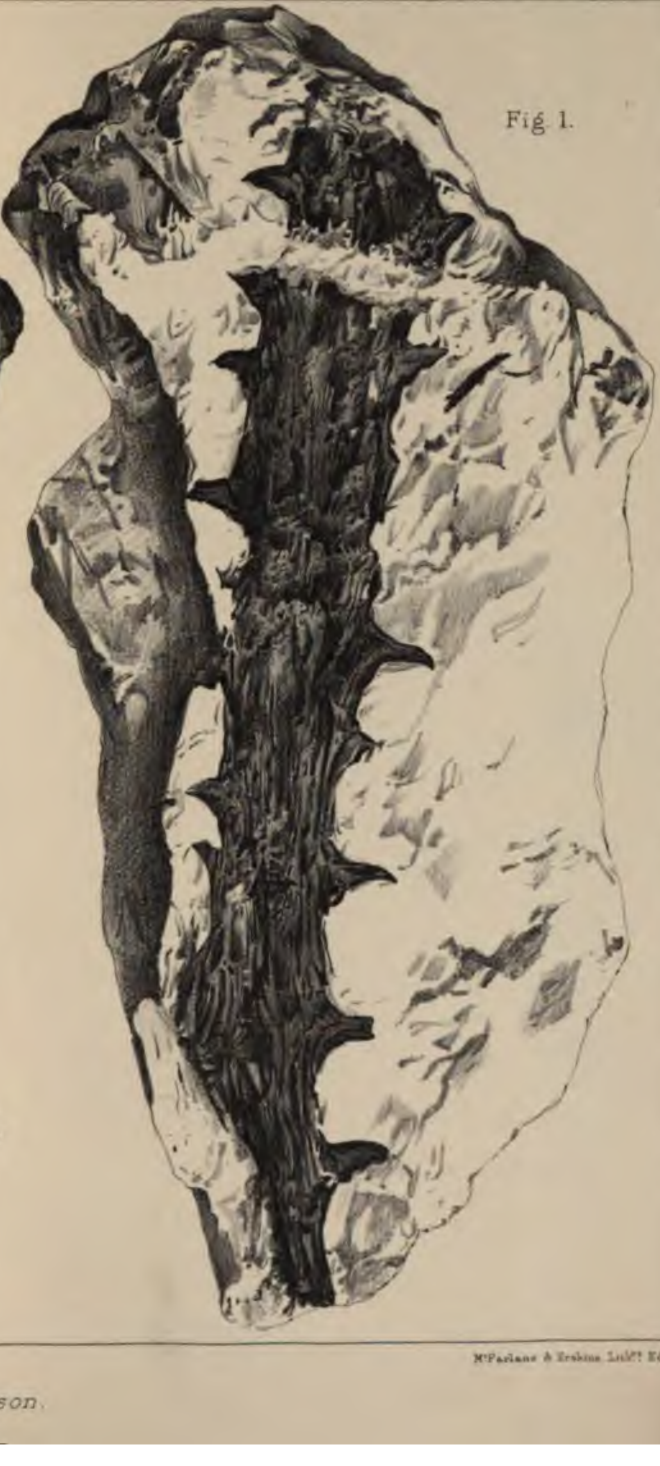


Fig. 1.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXIII.

Wednesday, 15*th November* 1893.—Robert Kidston, F.R.S.E., F.G.S., retiring Vice-President, in the Chair.

The retiring Vice-President delivered the following opening address, "On the Various Divisions of British Carboniferous Rocks as determined by their Fossil Flora":—

Gentlemen,—The study of Palæontology naturally suggests three lines of investigation—1st, the vertical and horizontal distribution of the organisms, or their distribution in time and space; 2nd, their affinities with recent and other extinct forms; and 3rd, the part fossils play in affording data for the identification of strata which may be widely separated in space.

On the third of these heads, especially in regard to British Carboniferous rocks, I wish to make a few remarks this evening.

This subject is neither new nor free from differences of opinion, especially in regard to the value of fossils in determining or correlating strata. The Mollusca have usually been selected as the most suitable organisms for this purpose—chiefly on account of their wide distribution, their great numbers, and the generally good condition in which they occur—their calcareous shells being very favourable for their preservation.

Other animal remains have also been used as tests for the age of rocks, but till comparatively recently, in Britain, fossil plants have been entirely neglected for this purpose. On the Continent, however, much has been done by the aid of fossil plants in correlating and dividing the Carboniferous rocks into zones.

The use of fossil plants for such purposes is fully justified in the admirable works of Geinitz, Weiss, Zeiller, Grand' Eury, Renault, and others.

At present I shall restrict my remarks to the correlation of the British Carboniferous rocks among themselves, and omit any reference to their foreign representatives, as the time at my disposal will not admit of my entering upon such a wide subject.

In many of our Formations fossil plants are comparatively rare, and in such cases the Mollusca or other animal remains must serve as tests for the correlation of such rocks; but where plants occur in sufficient quantity, I believe that in all cases they give the surest index of age.

I am aware that this is not the view generally taken, chiefly, I believe, because fossil plants have not been studied to nearly the same extent that animal remains have been.

In Britain few of our palæontologists have devoted themselves to the study of the fossil flora; but those who have gone into the subject carefully, have, I believe, fully recognised the value of plants for correlating strata. I need only instance two British palæontologists whose work proves this statement—Mr Clement Reid and Mr J. Starkie Gardner.

Sir Archibald Geikie expresses a different opinion from that which I have adopted. He says, in writing of the Carboniferous system: "Fossil plants do not serve so well for purposes of geological classification as animal fossils;"[1] and again, "As the conditions for the preservation of organic remains exist more favourably under the sea than on land, relics of marine must be far more abundantly conserved than those of terrestrial organisms. This is true to-day, and has doubtless been true in all past geological time. Hence, for the purposes of the geologist, fossil remains of marine forms of life far surpass all others in value. Among them there will necessarily be gradations in importance, regulated chiefly by their possession of hard parts, readily susceptible of preservation among marine deposits."

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[1] Text-Book of Geology, 2nd ed., p. 732.

. . . "Of all the marine tribes which live within the juxta-terrestrial belt of sedimentation, unquestionably the Mollusca stand in the front rank as regards their aptitude for becoming fossils. In the first place, they almost all possess a hard, durable shell, composed chiefly of mineral matter, capable of resisting considerable abrasion, and readily passing into a mineralised condition. In the next place, they are extremely abundant both as to individuals and genera. They occur on the shore up to high-water mark, and range thence down into the abysses. Moreover, they appear to have possessed these qualifications from early geological times. In the marine Mollusca, therefore, we have a common ground of comparison between the stratified formations of different periods. They have been styled the alphabet of palæontological inquiry. It will be seen as we proceed, how much, in the interpretation of geological history, depends upon the testimony of sea-shells.

"Turning next to the organisms of the land, we perceive that the abundant terrestrial flora has a comparatively small chance of being well represented in a fossil state; that indeed, as a rule, only that portion of it which the leaves, twigs, flowers, fruits, or trunks are blown into lakes, or swept down by rivers, is likely to be partially preserved. Terrestrial plants, therefore, occur in comparative rarity among stratified rocks, and furnish in consequence only limited means of comparison between the formations of different ages and countries."

. . . "Another character determines the relative importance of fossils as geological monuments. All organisms have not the same inherent capacity of persistence. The longevity of an organic type has, on the whole, been in inverse proportion to its perfection. The more complex its structure, the more susceptible has it been of change, and consequently the less likely to be able to withstand the influences of changing climate and other physical conditions. A living species of Foraminifer or Brachiopod, endowed with comparative indifference to its environment, may spread over a vast area of the sea-floor; and the same want of sensibility enables it to endure through the changing physical conditions of successive geological periods. It may thus possess a great range both in space and time. But a highly specialised mammal is usually confined but to a limited extent of country, and to a narrow chronological range."[1]

This extract fully illustrates the views generally held by palæontologists, and the reasons why they hold them. But the very reasons on which they place so much importance on the Mollusca for the identification of strata are those which to me seem to make them most unsuitable for such purposes.

The opinions I hold on this subject may not be generally applicable to all the formations, nor do I claim that they are, but they certainly apply to the Carboniferous formation, and it is only in connection with Carboniferous rocks that I can personally speak.

One concrete example may illustrate why, in Carboniferous rocks, the Mollusca are not so suitable as plants for determining horizons.

When sinking the shaft of the Hamstead Colliery, Great Barr, near Birmingham, 450 feet of red and purple shales, marls, and sandstones were passed through before meeting with the Middle Coal-Measures. These upper rocks had been mapped by the Geological Survey as Permian; but, from the evidence derived from the plants, which were carefully collected by Messrs F. G. Meacham, M.E., and H. Insley, who were in charge of the work, it was shown that these shales belonged to the Upper Coal-Measures.[2]

The Mollusca met with were also preserved, though unfortunately some of the specimens collected were destroyed through an accident. From those preserved, Dr John Young identified the following:—

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[1] Text-Book of Geology, 2nd ed., p. 601.

[2] See Trans. Roy. Soc. Edin., vol. xxxv., p. 317, 1888.

Productus semireticulatus, Martin.
„ *scabriculus*, Maitin.
Edmondia rudis, M'Coy.
Schizodus sp., allied to *S. carbonarius*, Portl.
Modiola lingualis, Phill.
Anthracosia Urei, Flem.
Leda attenuata, Flem.
Goniotites sp., allied to *G. excavatus*, Phill.

An *Euomphalus* was also got, but was unfortunately destroyed before I saw the collection.

Leaving out of consideration those individuals which are only generically identified, two of the species, *Modiola lingualis* and *Leda attenuata*, have been recorded from the upper beds of the Calciferous Sandstone Series; *P. semireticulatus*, *P. scabriculus*, and *Edmondia rudis* are frequent in the Carboniferous Limestone Series of Scotland; while *Anthracosia Urei* is generally restricted to the Lower Coal-Measures. Anyone judging of the age of these rocks from the Molluscan remains, would, without doubt, class them as Lower Carboniferous, whereas they are certainly of Upper Coal-Measure age.

This case is not an isolated one, and Dr John Young has referred to such occurrences in his paper entitled "Notes on the Occurrence and Range of *Lingula* in the Carboniferous Series of the West of Scotland."[1] Speaking of the apparent extinction and reappearance of an organism in a higher horizon, the paper concludes with the following remarks:—"Of such changes we have evidence in several of our coal seams, formed of the remains of a terrestrial vegetation accumulated in swamps at or near the sea-level, and now found to be overlaid by a great thickness of fossiliferous marine strata. But wherever we find a sudden extinction of the organic life in any stratum, we are not to suppose that such extinction was universal. In most cases it must have been comparatively local, for a total extinction would imply a new creation of the same forms in every succeeding age of strata in which they are met. The most probable supposition is, that during all the long geological ages in which our fossiliferous strata were being deposited, or from the first appearance of life on our globe, there never has been at any one time a total extinction of the flora or fauna from the remote period till the present time; and when we find in our Coal-Measures the constant reappearance of certain well-known species, after each local extinction in higher and higher stages of strata in the same locality, we are naturally led to conclude that, while they became extinct over these tracts, they must have continued flourishing in other parts of our Carboniferous sea, and that they spread from these spots into their old localities wherever the condition of the sea-bottom again became favourable to their growth and development."

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[1] Trans. Geol. Soc. Glasgow, vol. ii., p. 144.

In a letter from the same writer, dated 26th October 1887, Dr Young further says: "There can be no doubt of the repeated occurrence in higher and higher horizons of many of the marine and fresh-water forms of life found in our Scottish Coal-Measures. Since this paper" (that quoted above) "was printed, I have been able to trace other forms besides *Lingula*, that range from the very lowest fossiliferous marine beds up into that of the Permian formation. It is, therefore, quite unsafe to take any one organism as characteristic of any special horizon, for closer investigation of the strata in any country is constantly proving their recurrence or occurrence in higher or lower beds."

It is seen, therefore, that not only genera, but even species, of Mollusca, have persisted through a vast period of time in *Carboniferous rocks*, and, in some cases, throughout the whole of this great period, extending from the Calciferous Sandstone Series to the Upper Coal-Measures. We can easily understand how this has been brought about, for marine, or fresh-water animals, endowed with the power of locomotion, would migrate to more favourable localities, whenever the conditions of the area in which they lived became unfavourable for their life and development. As a rule, we may conclude that these changes unfavourable for their growth and development came on gradually, such as the sinking or elevation of the sea-bottom, or alterations in the nature and amount of sedimentation. There may, and apparently have been, sudden extinctions of marine life in certain areas, as in the Upper Old Red Sandstone at Dura Den, where the fish have been overwhelmed and killed in shoals, but such cases would, probably, be rare, and I think we are warranted in concluding that marine organisms were able, in the great majority of cases, where the physical conditions necessary for their growth altered, to preserve themselves by migration. The proof of this is seen in the repeated recurrence of the same organism in higher and higher horizons—and it is this very capability of migration and self-preservation of the species through vast periods of time, which make the Mollusca, and marine organisms generally, *so much more unsuitable than plants for determining horizons in the Carboniferous formation.*

If we examine the conditions under which land plants grow, we see how unfavourable their conditions are, when compared with those of marine animals, for the preservation of their existence when any physical change took place which was unsuited to the conditions necessary for their life. Plants being fixed to the ground on which they live, subsidence, to even a slight extent, would be sufficient to cause their destruction and subsequent envelopment in mud and silt, as it is highly probable that they grew mostly on flat marshy tracts little elevated above the sea-level.

Even elevation of the land would, probably, be little less fatal to their existence, by bringing about a drier situation with a probable less humid atmosphere. Of course it is quite unlikely that a complete extinction took place over large areas, but notwithstanding we fully admit this, there still remains the cardinal fact that plants are provided, only to a limited extent, with the means of preventing the evil consequences of a change of physical conditions, when compared with the advantages for preservation of their life possessed by organisms endowed with the power of locomotion. Some species of fossil plants persisted much longer than others, but even in the case of those which persisted longest, their range in time is not nearly so great as that of their contemporary Molluscs.

If we divide the Carboniferous formation into Upper and

Lower Carboniferous, and these into their minor divisions as shown in the following table,—

Upper Carboniferous.	Upper Coal-Measures.
	Middle Coal-Measures.
	Lower Coal-Measures.
	Millstone Grit Series.
Lower Carboniferous.	Carboniferous Limestone Series of Scotland (= Yoredale Rocks of England).
	Calciferous Sandstone Series of Scotland (= Mountain Limestone of England),—

we find that though certain species of shells extend from the Calciferous Sandstone Series into the Upper Coal-Measures, I do not know a single species of plant found in the Lower Carboniferous that occurs in the Upper Carboniferous. So far as I have been able to ascertain, there is not in Britain one species common to both of these great divisions. Between the top of the Carboniferous Limestone Series and the base of the Millstone Grit, an enormous period of time is unrepresented by any rock in Britain—a period so great, that during its existence a complete change took place in the flora.[1]

But irrespective of this great break in the deposition of Carboniferous rocks in Britain, many of the Calciferous Sandstone species do not pass into the Carboniferous Limestone Series, though they have some species in common; still the floras of the two periods are very different as a whole.

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[1] Of course *Stigmaria* occurs both above and below the Millstone Grit, but *Stigmaria* was the root of *Lepidodendron* and *Sigillaria*, and probably of *Lepidophloios* and *Bothrodendron*. All these genera occur in both the Upper and Lower Carboniferous rocks, but in each division are represented by different species. All that can be said of *Stigmaria* is that it is the root of one or other of the plants of these genera. In no case, so far as I know, can we refer any given *Stigmaria* to any given *Lepidodendron*, etc. All we can say is that the *Stigmaria* found in Upper Carboniferous rocks are the roots of Upper Carboniferous species, and those found in Lower Carboniferous rocks are the roots of Lower Carboniferous species. The same remarks may be made of *Lepidastrobus variabilis*, L. and H., which is an "aggregate species," and of some of the *Lepidophylli*—even the named species of which evidently contain the leaves or bracts of more than one plant.

Again, we find very few of the Lower Coal-Measure plants passing up into the Upper Coal-Measures, and even the few that do so pass up are among the rarest of Upper Coal-Measure species, whereas they are the commonest species in the Lower Coal-Measures: even from the Middle Coal-Measures very few pass into the Upper Coal-Measures. The Middle and Lower Coal-Measures have a much greater similarity in their flora, but here, too, we find each series characterised by its fossil plants.

But before passing from the more general questions which affect the whole subject of the value of palæontological evidence in determining the age of rocks, the very important question as to the practical application of the principle demands some attention, for on the use we make of our tools depends the value of the work done.

Some palæontologists have accepted the occurrence of a single species or even specimen as sufficient evidence for the determination of a horizon. This is an abuse of palæontology —and such treatment of fossils has brought the science into disrepute, if not contempt, in some quarters; but for this palæontologists, and not palæontology, are to blame.

From the occurrence of *Alethopteris* (*Pecopteris*) *Serlii*, Brongt. sp., in the Forest of Wyre, Worcestershire, the late Dr Stur correlated these beds with the Upper Coal-Measures.[1] Now, though *Alethopteris Serlii* is a *characteristic* Upper Coal-Measure plant, and is extremely abundant in that horizon, it also occurs, though very rarely, in the Middle Coal-Measures. If instead of fixing upon a single species as the test of age, the other fossils found associated with *Alethopteris Serlii* in the Forest of Wyre had been taken into account, it would have been evident that the Coal-Measures of the Forest of Wyre were of Middle Coal-Measure age.

In fossil botany, it is utterly unsafe to fix upon one species for determining horizons, and altogether to ignore the other plants with which it is associated. It must always be borne in mind that the *presence* of certain species is not always of itself sufficient data for the determination or correlation of horizons, for equally important is the *absence* of others.

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[1] Verhandl. d. k. k. geol. Reichs., 1884, No. 7, pp. 135-141.

There are certain cases, I admit, where the occurrence of a single species goes far to prove the age of the rocks from which it was derived. Experience has taught us that a greater palæontological value for determining horizons belongs to certain genera and species than to others, and there are many cases where certain plants and animals have never been found but on one particular horizon; still, great care is necessary in dealing with such negative data, for there is always the possibility of such organisms being found in other horizons.

If, on the other hand, we deal with a collection of fossils, containing a greater or less number of species, the risk of giving undue importance to any given species is done away with, and here another very important factor enters in—the *relative proportion* of the species.

The value of this *relative proportion* of the species is well illustrated when dealing with the correlation of the various divisions of the Coal-Measures, as developed in Britain.

If one carefully examines the floras of the Upper, Middle, and Lower Coal-Measures, it is found that of the few species which extend through all the divisions, such species are usually common in one, or even two of the divisions, and extremely rare or absent in the other division or divisions, as the case may be; hence any possibility of giving an undue importance to the rare occurrence of a species, which may be common in some other horizon, is entirely eliminated by taking into consideration the prevalence of the other species with which it is associated, and which may be extremely rare or quite unknown in the other divisions.

Any characters derived from colour or lithological characteristics of strata are of little use in the correlation of horizons, except in restricted areas. In many cases where colour has been accepted as evidence of the age of a rock, it has led to error. On one occasion Professor Hull says: "In connection with the colour of these sandstones, it may be stated that it has been found in the neighbourhood of Rainford, that sandstones, which at the surface assume a purple colour, are found to be brown or grey where pierced by coal-shafts, and this is probably one of the distinguishing characters of Coal-Measure sandstone as compared with those of Permian age."[1]

Such characteristics do not hold for the separation of Permian from Carboniferous rocks. The Upper Coal-Measure red shales, which partly surround the South Staffordshire Coal Field, have all the *colour characteristics* of Permian rocks, as generally defined, and are mapped as Permian on the Geological Survey Maps; but their fossil plants have shown them to be of undoubted Upper Coal-Measure age. I do not think that the *colour* of rocks gives any infallible indication of their age; it is certainly no test between Corboniferous and Permian rocks. The red colour of the rocks under consideration is adventitious, and may result from subsequent staining, derived from rocks that once overlay them, though now removed.

The following tables show the correlations of the Scottish and English Carboniferous rocks, as proposed by some of the most recent writers on the subject.

The first is taken from the *Reports* of the Congrès géologique international, 4me session, London, 1888, Appendix B; "Reports on Classification and Nomenclature;" 2nd edition, Report of Sub-Committee, No. IV. "Carboniferous, Devonian, and Old Red Sandstone," p. 153 (1891).

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[1] Mem. Geol. Survey England and Wales—The Geology of the Country around Prescot, Lancashire, pp. 10, 11. London, 1882.

TABLE I.

Divisions of the Carboniferous System. By Professor E. Hull.[1]

DIVISIONS.	STAGES.	ENGLAND AND WALES.	SCOTLAND.
Upper.	G	Upper Coal-Measures of Manchester, etc., Ackworth Rock, etc.	Red Sandstones of Bothwell, etc.
	F	Middle Coal-Measures, with thick coal seams.	"Flat Coal Series" or "Upper Coal Series."
Middle.	E	Gannister Beds or Lower Coal-Measures, with marine fossils.	"Slaty black-band" Ironstone Series.
	D	Millstone Grit Series.	"Moorstone Rock" (or Roslin Sandstone).
	C	Yoredale Series.	Upper Limestone Series resting on "Lower Coal and Ironstone Series."
Lower.	B	Carboniferous Limestone or "Mountain Limestone," Scaur Limestone (Sedgwick).	Lower Limestone Series.
	A	"Tuedian Group" (Tate), Lower Limestone Shale, etc., Barnstaple and Pilton Beds (Hull), and Marwood Beds of Devonshire.	Calciferous Sandstone Series in two groups.

In a somewhat similar table, given in the 4th edition "Coal Fields of Great Britain," pp. 86, 87, an additional column is added, in which is given the "Conditions of Deposition." Stages G and F, "Essentially estuarine and lacustrine, with intrusions of the sea at long intervals." E, D, and C, "Essentially marine, rarely estuarine (sea shallower than in Stage B). B and A, "Essentially marine, and deep-sea beds (except occasionally in Scotland, where lacustrine or estuarine beds occur)."

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[1] The Irish and Foreign columns are omitted here. See Compte rendu—Congrès géologique international, 4me session, London, 1888 (issued 1891), p. B/153.

From a perusal of the "Report of the Sub-Committee on the Carboniferous, Devonian, and Old Red Sandstone Formations," one is almost led to think that its members were not unanimous in their views on the correlation of the various Carboniferous horizons, nor of the most suitable terms to be adopted for them. The chief feature of the Report is its suggestion of uncertainty.

One of the conclusions they arrived at was that "no hard and fast line can be drawn between the Lowest Carboniferous rocks and those of the Devonian or Old Red Sandstone Series."[1]

I presume that the Devonian or Old Red Sandstone Series referred to here means only the Upper Old Red Sandstone. Upon this the basement beds of the Carboniferous formation lie conformably, but the palæontology of the Upper Old Red Sandstone in Scotland is so essentially distinct from that of the Lower Carboniferous, that it does not seem to me possible to unite the Upper Old Red Sandstone with the Carboniferous formation.

The fact that the basement beds of the Carboniferous formation lie conformably on the Upper Old Red Sandstone, need not lead to the inference that they are parts of the same formation.

No one could be more explicit on this subject than Sir Archibald Geikie. He says: "Geological history, therefore, if its records in the stratified formations were perfect, ought to show a blending and gradation of epoch with epoch, so that no sharp divisions of its events could be made."[2]

I also give here, from the same source from which the previous table is taken, the "Generalised Index of the Carboniferous Rocks of Scotland," by Mr B. N. Peach, F.R.S.[3]

This gives an excellent geological sketch of the divisions of the Carboniferous formation as developed in Scotland. I shall have occasion to refer to this table again, when dealing with the correlation of the Scottish and English Carboniferous rocks.

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[1] *Loc. cit.*, p. B/140. This conclusion of the committee, mentioned while treating of the Carboniferous rocks, scarcely agrees with that stated on p. B/155 when dealing with the Old Red Sandstone. . . . "So far as England is concerned, it seems a step in the right direction to substitute the name Carboniferous Basement Beds for that of Upper Old Red Sandstone, and to retain the venerable name of Old Red Sandstone for the lower division. *In Scotland, however, the distinctive character of the Upper Old Red Sandstone is far too pronounced to make such a nomenclature suitable.*" (Compare note in Report given here on p. 197, Note 2.)

[2] Text-Book, 2nd edition, p. 629.

[3] *Loc. cit.*, p. B/150.

TABLE II.

Generalised Index of the Carboniferous Rocks of Scotland. By B. N. Peach, F.R.S.

Coal-Measures.	Upper or Red Sandstone Group.	An upper group of red sandstones, shales, etc., with thin coals, probably equivalent to the Pennant Grit of England. This group rests with a gentle unconformity on the beds below.
	Lower or Black Group.	Alternations of sandstones, shales, fireclays, with coal seams, forming the greater portion of the coal-fields of Scotland. Similar beds, but with thick sandstones, and the coal seams becoming lenticular. Probably the Gannister Beds of England. The "Slaty Band Ironstone" is used conventionally as the base line.
	Millstone Grit.	Sandstones, shales, and coarse fireclays, with lenticular seams of coal. These pass up into the Coal-Measures above, and down into the Carboniferous Limestone below, the divisions being arbitrary in both cases. The base line is constituted in the eastern side of Scotland by the Castlecary Limestone, and in the western (where the Castlecary is absent) by the Arden or Calmy Limestone.
The Yoredale Rocks of England. Carboniferous Limestone Series of Scotland.[1]		An upper group of sandstones and shales containing at least three limestones, viz., the Castlecary, the Calmy or Arden, and the Index Limestone, and occasionally some workable coals. The Index Limestone receives its name from its position immediately above the workable coal seams of the next group. A middle group of sandstones and shales, with several workable seams of coal and ironstone. A lower group of sandstones, shales, etc., with three or more bands of limestone, of which the Hurlet is the most important. The top of the group is taken arbitrarily at the Hosie Limestone. The base line is formed over the greater part of Scotland by the Hurlet Limestone, but in parts of Ayrshire and Lanarkshire is drawn at the Wee Limestone, 60 feet below the Hurlet.

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[1] "Carboniferous Limestone Series of Scotland. This name, however, is now used in England for the Yoredale Rocks and Carboniferous Limestone collectively, as previously stated.—A. S."

The statement referred to here is that given on pages 138, 139 of the same Report, from which the following is extracted:—

"In the case then of such a formation as the Carboniferous, it seems to me that the right thing is for each district to have its own subdivisions and its

The Carboniferous Limestone Series of England. Calciferous Sandstone Series of Scotland.	Upper or Cement Group.	An upper or "Cement-stone" group, so-called, because it is made up, in some districts, of alternations of blue shaly clays and argillaceous limestones. But in the Edinburgh area it consists in the upper part of grey sandstones and shales with seams of oil shale and a fresh-water limestone (the Burdiehouse Limestone). On the coast of Fife, on the other hand, the beds are chiefly marine, and more like the overlying series. These changes are attributed to the beds having been deposited on an uneven surface, which was not all enveloped until the Calciferous Series was completed.
	Lower or Red Sandstone Group.	A lower or Red Sandstone group. No particular band is used to divide this from the preceding. On the Borders and in Berwickshire a platform of contemporaneous volcanic rock serves for a boundary. But in Haddington volcanic activity occurred at a later date, and in other parts towards the close of the Cement group, or far on in the Carboniferous Limestone Series. The group consists chiefly of red and green marls and sandstone, passing down into, and barely distinguishable from, the Upper Old Red Sandstone. The latter, however, is often absent, in which case the Red Sandstone group rests unconformably on the Lower Old Red Sandstone or Silurian Rocks.[1]

Upper Old Red Sandstone.[2]

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own nomenclature, and that great caution should be exercised in attempting to correlate the divisions of one district with those of another."

"The system, commonly in use in educational books throughout the country, of placing the local subdivisions of each district in a vertical column, and of arranging those which are supposed to be equivalent along a horizontal line, may, in Professor Green's opinion, be of use as an aid to the understanding, but if intended to represent the way in which nature works, can only be mischievous."

"The carrying out of the system leads to a forced and unnatural classification in all districts, except in those which happen to have been selected as forming an area of typical development, and gives an appearance of synchronism which is generally untrue."

"The particular case referred to by Professor Green has been met by the Geological Survey recently. The term Carboniferous Limestone having proved inapplicable, it was made more elastic by adding the word Series. Thus the Yoredale Rocks and Carboniferous Limestone are now grouped together under the name of Carboniferous Limestone Series. The name Bernician, which had been used by S. P. Woodward in 1856 for the Lower Carboniferous Rocks, was independently suggested by Prof. G. A. Lebour in 1875, for the Carboniferous Limestone Series in those parts of the North of England, where the Carboniferous Limestone and the Yoredale Beds blend in such a way as to form a link between the Yorkshire and the Scottish types of the series. The lower part of the Lower Carboniferous (the Calciferous Sandstone of Scotland and the Upper Old Red Sandstone or Carboniferous Basement Beds) are included by many authors under the name Tuedian, originally proposed in 1855 by Mr Tate for the Calciferous Sandstone Series, and subsequently advocated by Professor Lebour."

[1] The Red Sandstone group is now mapped by the Geological Survey of Scotland as Upper Old Red Sandstone.

[2] "Corresponding to the Carboniferous Basement Beds of England. The same beds are referred to by both names on the Border."

In regard to the note referring to the union of the Yoredale Beds and the Mountain Limestone, under the name of the "Carboniferous Limestone Series," it seems to be a retrograde movement in nomenclature.

I presume that there is a general consensus of opinion that the Yoredale Beds, or the upper portion of them at least, are the equivalent of the Carboniferous Limestone Series of Scotland. I have seen no fossil plants from the Yoredale Beds, and therefore offer no opinion on their relationship to the Carboniferous Limestone Series of Scotland,—my knowledge of the series being entirely gained from written descriptions. But this is known, that the Yoredale Beds overlie the Mountain Limestone of England, and, further, it is also known, that the Mountain Limestone of England is the equivalent of the Calciferous Sandstone Series of Scotland;[1] therefore the probability is, that the Yoredale Beds are the equivalents, in whole or in part, of the Carboniferous Limestone Series of Scotland. That being the case, I do not think they should be classed as merely an upper portion of the Mountain Limestone of England. If the position of these Yoredale Beds is doubtful, so much greater is the necessity of retaining them under their old name. Their very union with the Mountain Limestone under one name is against the Committee's own suggestion as to the advisability of using "local subdivisions." In any case, the note as given to Mr Peach's sketch section, would lead one to infer that the writer of the note accepted the position given to the Yoredales by Mr Peach, but then said that the Carboniferous Limestone Series of Scotland and the Calciferous Sandstone Series of Scotland should unitedly be regarded as the equivalents of *their* Carboniferous Limestone Series (of England), which comprises the Yoredale Rocks and the Mountain Limestone.

This is working backwards. There is no doubt that the Carboniferous Limestone Series and the Calciferous Sandstone Series of Scotland form two well-defined series, and that the

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[1] Goodchild, Note on the Carboniferous Conglomerates of the Eastern Part of the Basin of the Eden—Quart. Jour. Geol. Soc., vol. xxx., 1874, p. 394.

Mountain Limestone of England is the equivalent of the Calciferous Sandstone Series of Scotland. The fact, then, that there is some difficulty in referring the Yoredale Beds to their equivalents elsewhere, or, even, in drawing a dividing line between them and the Mountain Limestone of England, is no reason why rocks, whose true position in Scotland is known, should be slumped together in order to bring them into conformity with the recently proposed Carboniferous Limestone Series of England, a term which has admittedly been introduced to get rid of a difficulty.

But, whatever be the position of the Yoredale Beds, the Carboniferous Limestone Series of Scotland is a clearly defined series, and distinctly separable from the Calciferous Sandstone Series on which it lies. This being so, it is very unfortunate, to say the least, that the members of the Committee who drew up the Report on the Classification of British Carboniferous Rocks, should have adopted the term of Carboniferous Limestone Series for certain rocks in England, the greater portion of which are known to be of older age than the rocks to which this term has been *previously applied in Scotland.*

If the proposal of the Committee be adopted, it can only lead to additional confusion in the classification of the Lower Carboniferous rocks of Britain.

The classification given by the Committee in their Table of the Divisions of the Carboniferous System as drawn up by Professor Hull,[1] seems to be founded not on palæontological evidence but on the physical conditions which have maintained during the formation of the strata,—conditions which are not indicative of age, and which have again and again recurred at different times.

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[1] See *ante*, p. 194.

GEOLOGICAL NOTES ON THE DIVISIONS OF THE CARBONIFEROUS FORMATION AS DEVELOPED IN BRITAIN.[1]

SCOTLAND.

UPPER COAL-MEASURES.

Typical Area in Britain.—Radstock and Farrington Series of the Somerset Coal Field.

There still remains some doubt as to the occurrence of this division of the Coal-Measures in Scotland. The late Mr E. W. Binney, in a paper entitled "Further Observations on the Carboniferous, Permian, and Triassic Strata of Cumberland and Dumfries,"[2] identified certain beds near Canonbie as Upper Coal-Measures. From some reddened shales at Penton Linns, about 3 miles east of Canonbie, I have seen a few specimens of fossil plants which were collected by Mr A. Macconochie of the Geological Survey of Scotland.

Among these were *Neuropteris flexuosa*, Brongt., and a *Pecopteris*, which if not *P. arborescens*, Schl. sp., is a species closely allied to it, but unfortunately the preservation of this latter specimen was too imperfect to allow of a satisfactory determination. *P. arborescens* I have hitherto only seen in the Upper Coal-Measures, and *N. flexuosa* in the Upper Coal-Measures and in the Transition Series lying between the Upper and Middle Coal-Measures in the South Wales Coal Field.

Without, however, expressing any definite opinion about the position of these Canonbie beds, it is tolerably clear that their place is well up in the Coal-Measures, and apparently not lower than the Middle Coal-Measures.

MIDDLE COAL-MEASURES.

Typical Area.—The Dudley Coal Field, South Staffordshire.

"The red measures overlying the coal-bearing strata."

"Coal-Measures $d^{5'}$" of the Geological Survey of Scotland.

In the general section of the rocks occurring in the Kilmarnock district, described in the "Explanation" to the

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[1] All reference to the associated volcanic rocks is omitted from these notes.

[2] Mem. Lit. and Phil. Soc. Manchester, vol. ii., 3rd ser., 1865, p. 343.

Geological Survey Map, Sheet 22,[1] the following description is given of the Coal-Measures in descending order:—

Coal-Measures consisting of—

(*b*) Red sandstones, marls, fireclays, and shales, etc., with Carboniferous plants. It contains no coal seams.

(*a*) A group of white and grey sandstones, dark shales, fireclays, ironstones, and coals.

The upper group of red sandstones (*b*) is conjectured to lie unconformably on the lower group (*a*).[2]

In some other districts, as in the Lanarkshire Coal Field, thin coal seams occur occasionally in the upper group of red sandstones, but they are of no economic value.[3]

These red beds are also seen overlying the coal-bearing series in Stirlingshire,[4] Fife, and the Dalkeith Coal Field, Midlothian.[5]

A most interesting section of these red measures—the $d^{5'}$ of the Geological Survey—has been described by Messrs Binney and Kirkby.[6]

It is seen on the coast of Fife between the river Leven and East Wemyss, and consists of red and purplish sandstones, shales and marls, blotched with yellow and green, varying in tone, but assuming a more or less pronounced red colour, with thin beds of impure coal, a thin bed of argillaceous limestone, and a bed of Entomostracan hæmatite. This series, as developed here, according to Messrs Binney and Kirkby's observations, lies conformably on the Lower Coal-Measures, and has a thickness of 947 feet.

One of the chief interests of this section is found in the fossil plants which have been collected from several of the beds. These red beds are generally very barren, and excepting

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[1] Mem. Geol. Survey of Scotland—Explanation of Sheet 22. Ayrshire (north part), with parts of Renfrewshire and Lanarkshire. Edin., 1872, p. 9.

[2] *Loc. cit.*, p. 22, paragraph 42.

[3] Mem. Geol. Survey of Scotland—Explanation to Sheet 23. Lanarkshire, Central Districts, 1873, p. 35, paragraph 69.

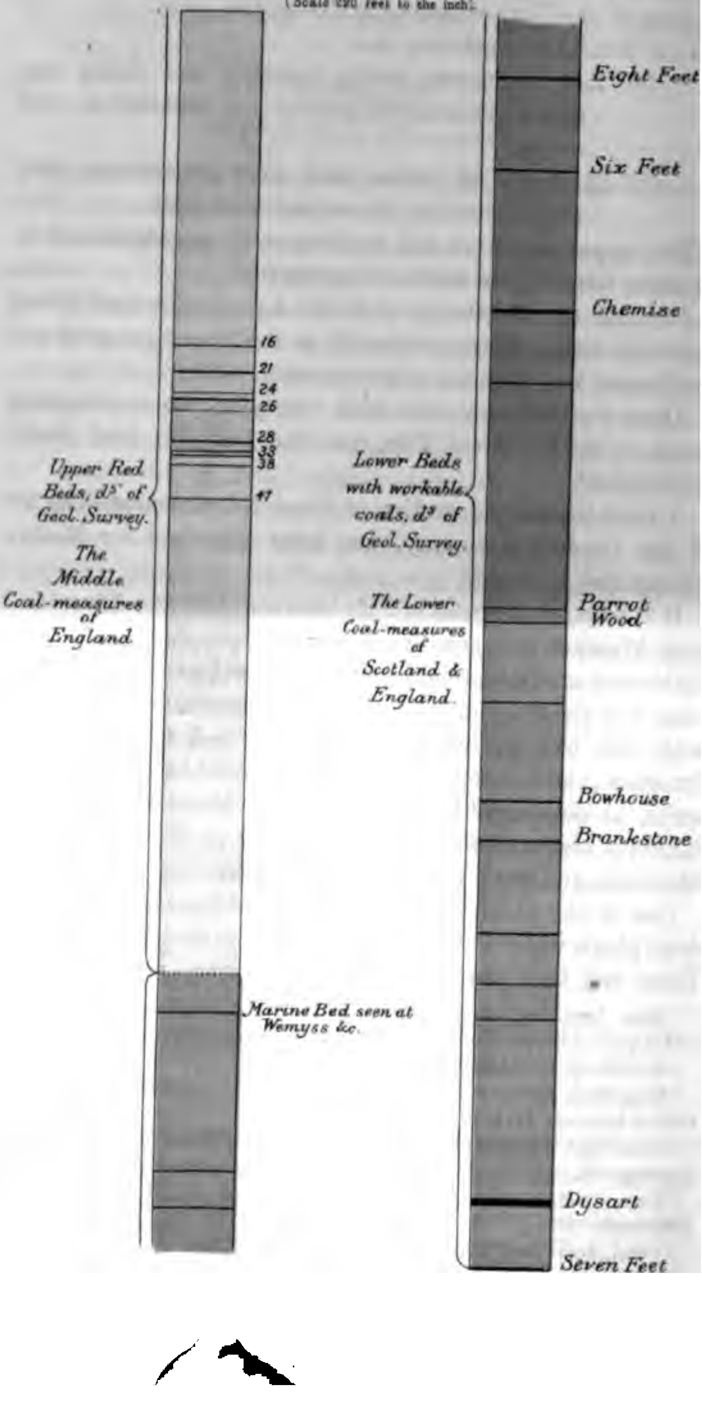
[4] Mem. Geol. Survey of Scotland—Explanation of Sheet 31 (1879), p. 42, paragraph 75.

[5] Mem. Geol. Survey of Scotland—Geology of the Neighbourhood of Edinburgh, 1861, p. 110.

[6] Quart. Jour. Geol. Soc., vol. xxxviii. (1882), p. 245.

VERTICAL SECTION OF THE COAL MEASURES OF FIFESHIRE.

(Scale 290 feet to the inch).


16
21
24
26
28
33
38
47
Upper Red Beds, d^5 of Geol. Survey.
The Middle Coal-measures of England
Marine Bed seen at Wemyss &c.
Lower Beds with workable coals, d^3 of Geol. Survey.
The Lower Coal-measures of Scotland & England.
Eight Feet
Six Feet
Chemise
Parrot Wood
Bowhouse
Brankstone
Dysart
Seven Feet

the specimens collected by Messrs Binney and Kirkby, I have not seen any fossil plants from them. These fossils were kindly submitted to me by Mr Kirkby, and from their examination I have been able to correlate these red shales (the $d^{5'}$ of the Geological Survey) with the Middle Coal-Measures of England.[1]

Mr Kirkby has kindly provided me with the accompanying section of the Fife Coal-Measures, on which are marked the beds in these red measures from which the fossil plants have chiefly been collected. The numbers given at the side of the section correspond to those given in the detailed section which accompanies the paper in the *Quarterly Journal of the Geological Society.*

The following are the plants collected:—

Bed 16:
    Alethopteris aquilina, Schl. sp.
Bed 21:
    Rhabdocarpus sulcatus, Presl. sp.
Bed 24:
    Neuropteris rarinervis, Bunbury.
Bed 28:
    Calamites ramosus, Artis.
        ,, *Suckowii*, Brongt.
    Calamocladus equisetiformis, Schl. sp.
    Sphenophyllum emarginatum (?), Brongt.
        Note.—Two small and fragmentary specimens, but probably belonging to this species.
    Pecopteris Miltoni (?), Artis.
        Note.—Specimens fragmentary, but I have little doubt as to their identity with this plant.
    Alethopteris aquilina, Schl. sp.
        Note.—Very plentiful.
    Mariopteris muricata, Schl. sp.
    Neuropteris Scheuchzeri, Hoffm.
        ,, *rarinervis*, Bunbury.

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[1] I did not see these fossils till after the publication of Messrs Binney and Kirkby's paper—the perusal of which was the first notice I had of their discovery. From the examination of the original specimens, I found that in several cases they had been misnamed, and it was only after correcting these errors of identification that the true position of these red beds was discovered.

Lepidodendron ophiurus, Brongt.
Lepidostrobus variabilis, L. and H.
Sigillaria camptotænia, Wood sp. (= *S. monostigma*, Lesqx.).
Cordaites sp.
Trigonocarpus Parkinsoni, Brongt., *forma olivæformis*, L. and H.
"*Algæ or rootlets*," Binney and Kirkby, *loc. cit.*, pl. vi.

Note.—These may possibly be the divided fruiting branchlets of a Calymmatothecous fern. They are not Algæ or rootlets.

Bed 33:

Neuropteris rarinervis, Bunbury.

Bed 47:

Calamites sp.
Neuropteris Scheuchzeri, Hoffm.
" *rarinervis*, Bunbury.
Lepidodendron, *cf. rimosum*, Sternbg.
Lepidophyllum lanceolatum, L. and H.
Trigonocarpus Parkinsoni, Brongt., *forma olivæformis*, L. and H.

The distinctly Middle Coal-Measure *facies* of these plants will be fully seen when compared with the plants from the same Measures of the English Coal Fields, where this division is much more developed.

In Mr Peach's Generalised Index (given *ante*, p. 196), he suggests that these red sandstones and shales are the probable equivalents of the *Pennant Grit* of England. This, however, cannot be their position, for the Upper Pennant of the South Wales Coal Field is of Upper Coal-Measure age, and the Lower Pennant of the same area forms a Transition Series, overlying the Middle Coal-Measures; and though the actual age of the Pennant Rocks of Somerset cannot be accurately determined, they overlie the Transition Series of Somerset, and are therefore considerably above the Middle Coal-Measures.

LOWER COAL-MEASURES.

"Lower or Black Group" of Mr Peach's Section. "Coal-Measures d^5" of the Geological Survey of Scotland.

This division contains all the workable coals of Coal-Measure age that occur in Scotland.[1]

Many writers on Scottish geology refer to this series as the Upper Coal-Measures in distinction to the coals worked in the Carboniferous Limestone Series, which they call the Lower Coal-Measures, Lower Series, or Lower Coals. But the so-called Lower Coal-Measures or Series are *not* Coal-Measures at all, and the loose application of the term "Coal-Measures" or "Coal Series" to all strata containing workable coal seams, has done much to create misconception as to the true position of the fossils derived from the coals of the Carboniferous Limestone Series or "Edge Coal" Series.[2]

MILLSTONE GRIT SERIES.

Although many geologists consider that there is no very definite stratigraphical line of separation between the Millstone Grit and the underlying Carboniferous Limestone Series, an enormous interval of time must have elapsed between the formation of these two series—an interval, the existence of which is proved by a complete change in the flora of the Millstone Grit from that occurring in the underlying Carboniferous Limestone Series.

It is well known that any change in the form of life has been a gradual and slow process, and that no sudden breaks occur in the chain of organic existence, and that any change undergone by the flora and fauna of bygone ages represents a longer or shorter period of time—a period the duration of which is measured by the changes produced; and its presence is as clearly proved by these changes as if it had been represented by the formation of beds of solid rock.[3]

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[1] Leaving out of account the Canonbie Coal Field, about whose geological position there remains some doubt.

[2] Such terms as the following are frequently met with in writings on Scottish geology :—"Lower Coals and Ironstones," "Upper Coals and Ironstones," "Upper or True Coal-Measures," "Scottish Upper Coal-Measures." To one unfamiliar with the geology of Scottish Carboniferous rocks, such terms are very confusing.

[3] It is known that precisely the same lithological type of rocks is found in the upper part of the Yoredale Rocks as occurs in the Millstone Grit itself. We may infer from this that similar conditions prevailed both before and after this palæontological break.

In the Millstone Grit we find that a complete change in the flora has taken place. There is an entire absence—as far as my knowledge goes—of a single species of plant which occurs in the underlying Carboniferous Limestone or Calciferous Sandstone Series. The Millstone Grit ushers in an entirely new group of plants—plants in many cases of a different *facies* from those which preceded them, but which, though rare in their occurrence, are identical in all respects with those of the overlying Lower Coal-Measures.

The Millstone Grit, by which term I understand rocks so named by the Geological Survey, in Lanarkshire, Stirlingshire, etc., would appear to be less developed in Scotland than in England, where in Lancashire, according to Professor Hull, it attains a thickness of 5500 feet.

In Scotland it contains many valuable beds of fireclay, which, in the neighbourhood of Garnkirk, Gartcosh, etc., are largely worked.[1]

CARBONIFEROUS LIMESTONE SERIES.

The Carboniferous Limestone Series is divisible into three groups, which are well seen in Stirlingshire and Linlithgowshire.

(*a*) A group of three or more limestones, with coals and thick beds of sandstone, etc.

(*b*) A group of sandstones, shales, etc., with beds of coal and ironstone.

(*c*) A group of sandstones, shales, etc., with several thick seams of limestone, and some coals and ironstones.[2]

This threefold division is characteristic of the series in Scotland.

Groups (*a*) and (*c*) are of a more marine type than group (*b*).

Fossil plants are much less plentiful in this series than in the Coal-Measures. Even in the shales associated with the coal seams, good specimens of fossil plants are very rare.

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[1] Palæontologically the Lower Coal-Measures and the Millstone Grit form one series.

[2] Mem. Geol. Survey of Scotland—Explanation of Sheet 31. Stirling (southern part), Lanarkshire (northern part), Linlithgow (western borders). Edin., 1879, p. 11.

CALCIFEROUS SANDSTONE SERIES.[1]

The term "Calciferous Sandstone" was first proposed by the late Mr Charles Maclaren in 1839 for this series,[2] on account of the impure limestones and calcareous sandstones which occur in it.

The Calciferous Sandstones, or "*Cement Stone*" *Series*, contain many valuable beds of bituminous shale, which are largely used in oil-making; it also contains estuarine limestone, the most important and best-known bed of which is the Burdiehouse Limestone. There are also some coal seams, usually very thin, but one of them, the Houston Seam, attains a thickness of 6 feet.

What was at one time regarded as a Lower or Red Sandstone group of this series, is now proved to be a portion of the Upper Old Red Sandstone as already mentioned.

The fossils got from the oil shale, which is a very fine-grained bituminous black rock, are usually in an excellent state of preservation. I have never seen any fossils surpass in beauty of preservation some which I possess from these beds. Owing to the shales being now broken up for the retorts by machinery, specimens from the oil shales are much more difficult to obtain. Formerly, when the shale was prepared for the retorts by manual labour, any good specimens met with were generally laid aside by the men engaged in splitting it up, and could easily be obtained from them.

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[1] I may here again repeat that the volcanic rocks occurring among the Carboniferous rocks of Scotland are entirely omitted from these descriptions, as they do not affect the point in view.

[2] A Sketch of the Geology of Fife and the Lothians, Edin., 1839, p. 70.

ENGLAND.

As the three divisions of the Coal-Measures—the Upper, the Middle, and the Lower—seldom occur equally well developed in any one coal field, I have selected for a short description of each, those coal fields where the general characteristics of the different divisions are well developed.

We shall also find that between these three well-marked divisions, a Transition Series occurs in one case, which forms passage beds from the Upper to the Middle Coal-Measures. The Upper, Middle, and Lower Coal-Measures, as well as the Transition Series, are, however, very distinctly defined by their fossil plants.

UPPER COAL-MEASURES.

Typical Area.—The Radstock and Farrington Series *of the Bristol and Somerset Coal Field.*

This field occupies a basin-shaped hollow, and its extreme length from north to south is 26 miles, and from east to west, if the outlying Nailsea basin be included, 24 miles. If the Nailsea basin be excluded (and it is omitted from the following notes), its width, from Bath in the east to Bristol in the west, is reduced to 12 miles.

The Somerset Coal Field is mostly overlaid by Secondary rocks.

The succession of Palæozoic rocks from above downwards is:

- Secondary Rocks.
- Palæzoic Rocks:
  - Carboniferous
    - Coal-Measures.
      - Radstock Series.
      - Farrington Series.
      - Pennant Rock.
      - New Rock Series.
      - Vobster Series.
    - Millstone Grit.
    - Carboniferous Limestone.
- Old Red Sandstone.

The Coal-Measures are separable into two divisions.

An upper division containing—

(*a*) Radstock Series.
(*b*) Farrington Series. } Upper Coal-Measures.

These are separated from the lower division by the Pennant Rock, under which come the

(*c*) New Rock Series.
(*d*) Vobster Series.

These two series, as will presently be shown, form a *Transition Series* between the Upper and Middle Coal-Measures.

I have seen so very few plants from the Pennant Rock of Somerset, that I am uncertain as to its relation with the two series between which it lies.

Radstock Series.

The Radstock Series consists of grey shales, sandstone, and coal. It contains eight seams, six of which are generally workable.[1]

The Radstock Series is separated from the Farrington Series by from 86 to 127 fathoms of unproductive strata, near the middle of which are certain very distinctive beds of *red shale* about 160 feet in thickness. Mr M'Murtrie states in regard to these red shales: "It has been suggested that these red shales may probably be found to have a much wider range than is generally supposed, as similar beds are found in some parts of the Midland Coal Field."[2] I have no doubt as to the correctness of the view here expressed, viz., that the red shales occurring in the coal fields of the midland counties are of the same age as the red shales occurring in the Upper Coal-Measures of the Somerset Coal Field. The proof of this will be seen in the list of the fossil plants which these red shales contain.

These red shales are well developed round the west, south, and east margins of the South Staffordshire Coal Field. They are described as Permian by the Geological Survey of England,[3] but I think it has been clearly shown—from the examination of the fossil plants collected while sinking through these rocks at the Sandwell Park trial boring near West Bromwich, and in the sinking of the shaft of the Hamstead Colliery, Great Barr, near Birmingham—that this series is not Permian but belongs to the Upper Coal-Measures. It had previously been conjectured that these rocks were of Coal-Measure age by Messrs Meacham and Insley.[1] The fossil plants collected at the above two workings will be referred to later on.[2]

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[1] M'Murtrie, Proc. S. Wales Institute of Engineers, vol. xii., No. 5, p. 429 *et seq.*, 1881.

[2] *Loc. cit.*, p. 430.

[3] Mem. Geol. Survey of Great Britain and of the Museum of Practical Geology—The South Staffordshire Coal Field, J. Beete Jukes, 2nd ed., p. 8. London, 1859.

The occurrence, therefore, of a small coal seam in the shaft at Bullock's Farm, near Spon Lane, South Staffordshire, is not at all unusual, when it is shown that the strata passed through are Upper Coal-Measures and not Permian, as originally supposed.[3]

Passing on to North Staffordshire, in the Potteries Coal Field, we again meet with these red shales, ironstones, and coals containing Upper Coal-Measure plants. A higher series of rocks, supposed to be Permian, overlies them. There is no break between the two series, and it seems highly probable that the whole are Upper Coal-Measures. There is no character, lithological or otherwise, so far as I know, by which they can be separated.

Carrying our investigations still farther north, into Lancashire, we find red shales and sandstones forming the Upper Coal-Measures of the Lancashire Coal Field.

In Yorkshire we likewise find, at Conisborough Pottery, what are most probably, if not certainly, Upper Coal-Measures, represented by red shales. This has been assigned to them as their probable age by Professor A. H. Green and Mr R. Russell.[4]

It is seen then, that these red shales and associated sandstones are traceable from Somerset to Yorkshire, and hold a constant position above the Middle Coal-Measures. In Somerset and Staffordshire their age is determined by fossil plants.[1] In the Lancashire and Yorkshire Coal Fields I have not yet been able to examine any fossil plants from them, but the Geological Survey describe the shales of Conisborough Pottery, Yorkshire, as "Red Beds with Coal Plants."

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[1] Report Brit. Assoc., Birmingham Meeting, 1886, p. 626, 1887. It has also been pointed out to me that these rocks have been coloured as Coal-Measures in the map which accompanies the 2nd edition of H. M. Woodward's "Geology of England and Wales," 1887. The map was prepared by Messrs Goodchild and Woodward.

[2] See page 211.

[3] Jukes, *loc. cit.*, p. 12.

Mem. Geol. Survey of England and Wales—Geology of the Yorkshire Coal Field, p. 75 (section). London, 1878.

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[1] The fossils collected during the sinking of the Sandwell Park trial shaft, West Bromwich, were, I believe, distributed before any careful list was drawn up. I have, however, seen in collections the following species from this source:—

Calamites Suckowii, Brongt.
,, *Cistii*, Brongt.
Calamocladus equisetiformis, Schl. sp.
Pecopteris arborescens, Schl. sp.
,, *Miltoni*, Artis sp. (= *P. abbreviata*, Brongt.).
Neuropteris Scheuchzeri, Hoffm.
Spiropteris sp.
Lepidophyllum lanceolatum, L. and H.

The fossil plants got in these red shales during the sinking of the shaft of the Hamstead Colliery, Great Barr, near Birmingham, were *—

Calamites varians, Sternb. var.
,, *Suckowii*, Brongt.
,, *undulatus*, Sternb.
Annularia stellata, Schl. sp.
Sphenophyllum emarginatum, Brongt.
Neuropteris rarinervis, Bunbury.
,, *ovata*, Hoffm.
,, *Scheuchzeri*, Hoffm.
,, *flexuosa*, Brongt.
Odontopteris Lindleyana, Sternb.
Pecopteris arborescens, Schl. sp.
,, *unita*, Brongt.
,, *Miltoni*, Artis sp.
Alethopteris decurrens, Artis sp.
,, *aquilina*, Schl. sp.
Lepidodendron Wortheni, Lesqx.
Lepidophyllum lanceolatum, L. and H.
Lepidostrobus variabilis, L. and H.
Sigillaria sp.
Stigmaria ficoides, Sternb. sp.
Pinnularia capillacea, L. and H.
Cordaites angulosostriatus, Grand' Eury.
Sternbergia approximata, Brongt.
Walchia imbricata, Schimper.

* Trans. Roy. Soc. Edin., vol. xxxv., part i., No. vi., p. 317, 1888.

I believe all these "red shales" are referable to the Upper Coal-Measures.

MIDDLE COAL-MEASURES.

Typical Area.—The Dudley Coal Field, South Staffordshire.

The Middle Coal-Measures contain a great wealth of coal, and from strata of this age are derived the greater portion of the coals at present being raised in England.

The whole of the coal seams of economic value in the South Staffordshire Coal Field are situated in the Middle Coal-Measures, which here lie unconformably on Silurian rocks. The most remarkable seam in this coal field is the "Thick Coal" or "Thirty Feet Seam," which, however, in the northern part of the coal field splits up into several separate seams. The "Thick Coal" is really formed by the running together of several beds of coal, varying in number from eight to fourteen, which rest either directly upon one another or are separated by thin beds of "clunch" or shale, called "partings."[1]

The "Thick Coal" is now mostly worked out in the neighbourhood of Dudley, so that the mining prosperity of that district now depends more on the other valuable seams, the total thickness of which, including the "Thick Coal," is about 65 feet.[2]

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[1] The Thick Coal of South Staffordshire, by Herbert W. Hughes, p. 1. Sheffield, 1885. Reprint from the Jour. of the Brit. Soc. of Mining Students.

[2] It is very generally stated that the Thick Coal is exhausted, and that it has been very badly worked. In reference to the first of these ideas, it may be said that there is now probably more unworked Thick Coal in South Staffordshire than there was *considered* to be twenty years ago; this being of course due to discoveries over the eastern boundary fault, and in the southern parts of the coal field. The author also believes that Thick Coal will eventually be found over the western boundary fault. H. W. Hughes, *ibid.*, Preface of reprint.

This paragraph refers to the discovery of the "Thick Coal" at Sandwell Park, West Bromwich, and at Hamstead Colliery, Great Barr.

In addition to coal, the South Staffordshire Coal Field contains beds of ironstone and fireclay, with their associated shales and sandstones.

In the Middle Coal-Measures of other coal fields in England, we find the same association of coal, ironstone, shale, and sandstone, and although they vary in the value of their mineral contents, they are characterised by the same features; but probably their general characteristics can be as well studied in the South Staffordshire Coal Field as in any other.

LOWER COAL-MEASURES,

or Gannister Beds of Lancashire and Yorkshire.

The Lower Coal-Measures occur in many of the English Coal Fields,—in the Potteries Coal Field, North Staffordshire, in the Lancashire Coal Field, in the Yorkshire Coal Field, and in the Northumberland and Durham Coal Field. They consist of sandstones, shales, coals, and ironstones, and call for no special remarks.

I now give a table showing the various divisions of the Coal-Measures which occur in the coal fields from which I have been enabled most fully to examine the fossil flora. Some of the other coal fields are at present engaging my attention, but as my investigations are not yet completed, they are not included in the table. In these partially examined districts, my difficulty lies in securing the cooperation of local collectors, without whose aid it is almost impossible to gain an adequate knowledge of the fossil plants, or the correct names of the seams from which the specimens have been collected.

COAL FIELDS.	UPPER COAL-MEASURES.	TRANSITION SERIES.	MIDDLE COAL-MEASURES.	LOWER COAL-MEASURES OR GANNISTER BEDS.
Bristol and Somerset Coal Field.	Radstock and Farrington Series, with workable coals and beds of red shales.	New Rock Series and Vobster Series, with workable coals.	Absent.	Absent.
South Wales Coal Field.	"Upper Pennant," workable coals.	"Lower Pennant," workable coals.	"White Ash Series," workable coals.	Absent.
Forest of Dean Coal Field.	Workable coals.	Absent.	Absent.	Absent.
Coal Field of the Potteries, North Staffordshire.	Red shales with thin coals.	Absent.	Workable coals.	Workable coals.
South Staffordshire Coal Field.	Red shales. No workable coals.	Absent.	Workable coals.	Absent.
Coalbrookdale Coal Field.	? Shales.	Absent.	Workable coals.	Absent.
Lancashire Coal Field.	Red shales. No workable coals.	Absent.	Workable coals.	Workable coals.
Yorkshire Coal Field.	Red shales. No workable coals.	Absent.	Workable coals.	Workable coals.

In the Northumberland and Durham Coal Field, the strata from the "High Main Coal" downwards, are shown by their fossil plants to be Lower Coal-Measures, if some of the lowest seams are not even in the Millstone Grit, as supposed by some geologists. I have not seen any fossils, so far as I can remember, from what is described as the "Upper Series" of this coal field,[1] so cannot express any opinion as to its age.

The coals worked in the Derbyshire Coal Field, near Doe Hill and Chesterfield, are of Middle Coal-Measure age, but I have not a full knowledge of this coal field.

There are other coal fields in England of whose flora little is known, and till the fossil plants from these areas have been examined more fully, it is unsafe to express any opinion as to which division of the Coal-Measures they occupy. The age of those seams from which I have seen fossil plants in these cases is easily determined, but possibly other horizons occur than those from which I have seen specimens. Hence, though I am able to say that one or other horizon of the Coal-Measures are present in certain areas, I cannot say that these are the only divisions of the Coal-Measures occurring in the districts here referred to, so, on the age of those coal fields whose flora is only partially worked up, I make no remarks at present.

MILLSTONE GRIT SERIES.

This series consists of grits, sandstones, white or reddish shales and clays, with a few thin coal seams.

In the Barnsley Coal Field, North Lancashire, according to Professor Hull, these rocks attain a thickness of 5500 feet.[2]

Owing to the pervious and coarse-grained nature of the sandstones occurring in the Millstone Grit Series, traces of fossil plants are very rare, and the shales hitherto have proved generally barren.

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[1] Hull, Coal Fields of Great Britain, 4th edition, 1881, p. 276.

[2] *Ibid.*, p. 218.

YOREDALE SERIES.

Typical Area.—The rocks so named in the Valley of the Yore, by the late Professor Phillips.

The Yoredale Rocks consist of alternations of shales and sandstones, with several thick beds of pure marine limestone. In the typical area the thickness is about 2000 feet.

The rocks referred to this horizon in North Staffordshire attain a thickness of 3100 feet,[1] while in South Lancashire it has a thickness of 2000 to 4000 feet.[2]

MOUNTAIN LIMESTONE.

Calciferous Sandstone Series of Scotland.

The Mountain Limestone is typically developed in the mountainous districts of North-West Yorkshire and the adjoining parts of Westmoreland. Here it consists of a vast thickness of marine limestone, generally characterised by singular purity of composition. Traced towards the north-west, it is found that these limestones become more and more split up by shales, and then, as the rocks are followed still farther to the north-west and the north, they are also split up by sandstones. The limestones concurrently become less pure and thin out successively from the bottom upwards. We therefore find in Northumberland the Mountain Limestone represented by a thick series of alternating shales, sandstones, and thin coals, among which the Limestones occupy a subordinate place, and are chiefly confined to the upper part of the series.

The rocks here have assumed the Calciferous Sandstone Series *facies*, and as such have long been recognised.[3]

At the meeting of the British Association at Birmingham in 1886, Mr Hugh Miller gave a preliminary note on the classification of the Northumberland members of this group, showing in tabular form the classification proposed by the late Mr George Tate between the years 1856-1868, that proposed by Professor Lebour between 1875-1886, and that adopted by himself. The last-mentioned is the one given here, which is a reinstatement of all the chief features of Tate's original classification. This Table shows so clearly the nature of the rocks comprising this group as developed in Northumberland, that any further remarks are quite unnecessary.[1] (Table, p. 218.)

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[1] Hull, Coal Fields of Great Britain, 4th edition, 1881, p. 184.

[2] *Ibid.*, p. 199.

[3] The earliest published suggestion, as far as I am aware, that the Mountain Limestone was of the same age as the Calciferous Sandstone Series of Scotland, is given by Mr J. G. Goodchild, in a paper entitled Note on the Carboniferous Conglomerates of the Eastern Part of the Basin of the Eden—Quart. Jour. Geol. Soc., vol. xxx., 1874, p. 399.

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[1] Report Brit. Assoc. for 1886, p. 674, 1887; see also W. Topley, The Work of the Geological Survey in Northumberland and Durham—Report Brit. Assoc. Newcastle-on-Tyne, 1889, p. 597, 1890.

T

Carboniferous Limestone Series—Northumbrian

Upper Limestone Series.	FELLTOP, OR UPPER CALCAREOUS DIVISION:—*F* *Grit to the zone of the Great Limestone.* Sandstones and shales; one or more beds of n including the Felltop Limestone; some coals.		*Asterocalamites scrobiculatus*, Schl. sp. *Araucaroxylon Withami*, L. and H. sp.
	CALCAREOUS DIVISION:—*From the Great Limestone to th f the Dun or Redesdale Limestone.* Many beds of good marine limestone; sandstones and s; coals.	1300–2500	
Lower Limestone Series.	CARBONACEOUS DIVISION (SCREMERSTON BEDS OF NORTHUMBERLAND:—*From the Dun or Redesdale Limestone to Tate's "Tuedian Grits."* Strata prevalently carbonaceous; limestones chiefly thin, many of them containing vegetable matter; coals.	800–2500	*Cardiopteris* (? *nana*, Eich.). *Lepidostrobus fimbriatus*, Kidston. *Stigmaria ficoides*, Brongt. sp.
	TUEDIAN DIVISION:—UPPER TUEDIAN, OR FELL SANDSTONE GROUP, THE "TUEDIAN GRITS" OF TATE:—*From the Carbonaceous Group to the Cement Limestones.* Great belt of massive Grits (Tweedmouth, Chillingham, the Simonside and Harbottle Hills, the Peel and the Bewcastle Fells). Shales greenish and reddish as well as carbonaceous-grey; coals rare, thin, or absent.	500–1600	
	LOWER TUEDIAN, OR CEMENT LIMESTONE GROUP:—*From the base of the Grits downwards.* Cement-stone bands passing (Rothbury, Bewcastle) into limestones; coals very rare; generally some coloration of the shales and sandstones.	500–1500	*Adiantites* sp. *Alcicornopteris convoluta*, Kidston. *Caulopteris minuta*, Kidston. *Lepidodendron Veltheimianum*, Stbg. " sp. *Lepidostrobus* sp. *Stigmaria ficoides*, Brongt. sp.
	BASEMENT CONGLOMERATES (UPPER OLD RED SANDSTONE); local.		

The term "Tuedian" of Tate Mr Miller suggests would be better translated into Tweed beds (Memoir, *loc. cit.*, p. 5).

GENERAL REMARKS ON THE DISTRIBUTION OF THE FLORA OF THE CARBONIFEROUS FORMATION.

I have already mentioned that in employing fossil plants for the purpose of ascertaining the groups, or divisions, of the Carboniferous formation that occur in Britain, and for the correlation of the isolated areas of these divisions that may lie in different parts of the country, I have not been guided by *data* afforded by the occurrence of any one species, but by the evidence derived from the examination of a general collection of the fossil plants from the rocks the age of which I wished to ascertain.

It is true, so far as our present knowledge goes, that certain plants appear to be restricted to certain horizons; but against the employment of such evidence as an infallible test of age, there is always the possibility of these species being yet found in other horizons. As examples of plants which appear to be restricted to one series of rocks, *Calymmatotheca affinis*, L. and H. sp., and *Calymmatotheca bifida*, L. and H. sp., may be mentioned. These have hitherto only been found in the Calciferous Sandstone Series, where in some localities they are plentiful.[1] But even if isolated examples of these were found, say in the overlying Carboniferous Limestone Series (= Yoredale Rocks), it would not alter their value as *characteristic* species of the Calciferous Sandstone Series.

If, however, in forming our opinions of the age of rocks from the fossil plants they contain, we take a view of their flora *as a whole*, errors arising from false values being placed upon individual species are entirely eliminated.

Nothing is more characteristic than the *facies* of a flora, a character which can only be observed when a representative collection of the whole flora of the series under consideration has been examined, and only under these conditions can the relative proportion of the species, another very important point, receive its proper value.

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[1] I am aware that these species have been reported from other horizons, but it has only been through error of identification.

With this explanation of the lines on which my investigations have been conducted, we may now pass on to the consideration of the plants which characterise those divisions of the Carboniferous formation, which have already been mentioned as occurring in Britain.

The fossil plants of the Carboniferous formation as developed in Britain, clearly indicate a great two-fold division of these rocks into—

A. UPPER CARBONIFEROUS.
B. LOWER CARBONIFEROUS.

Professor Hull has proposed a threefold division, viz.,—

UPPER CARBONIFEROUS.
MIDDLE CARBONIFEROUS.
LOWER CARBONIFEROUS.[1]

In his Middle Carboniferous he includes the Gannister Beds or Lower Coal-Measures, the Millstone Grit Series, and the Yoredale Series. If the Yoredales are the equivalents of the Carboniferous Limestone Series of Scotland, which I believe they are, there is included in his Middle Carboniferous certain groups which have *no* palæontological affinities whatever. The Carboniferous Limestone Series shares, in common with the Calciferous Sandstone Series (= Mountain Limestone of England), a peculiar group of plants, which essentially separates them from the rocks lying above them. Whereas the flora of the Lower Coal-Measures and Millstone Grit belongs to another palæontological group, which shows no close connection with the flora of the underlying rocks.

If any value is to be placed on vegetable palæontology, this threefold division of the Carboniferous Rocks is utterly untenable, and seems to have been founded on physical conditions alone — upon conditions undergoing constant change and frequently repeating themselves at different periods in the same area on higher horizons. Such physical conditions are not typical of age, and are therefore valueless for correlating periods of time.

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[1] See *ante*, p. 194.

The UPPER CARBONIFEROUS is divisible into—

(*a*) COAL-MEASURES;
(*b*) MILLSTONE GRIT;

and the LOWER CARBONIFEROUS into—

(*c*) CARBONIFEROUS LIMESTONE SERIES (*Scotland*)
(= *Yoredale Rocks of England*);
(*d*) CALCIFEROUS SANDSTONE SERIES (*Scotland*)
(= *Mountain Limestone of England*).

The COAL-MEASURES are further divisible into three groups:—

UPPER COAL-MEASURES.
MIDDLE COAL-MEASURES.
LOWER COAL-MEASURES.

In addition to these three groups there is a TRANSITION SERIES, forming passage-beds between the Upper and Middle Coal-Measures. Such Transition Series are quite what must be expected, and though there has not yet been detected any clearly defined Transition Series lying between the other divisions, they may yet be observed.

The following table shows the main groups into which the British Carboniferous Rocks are divisible, as determined by their fossil plants, and the correlation of the series in Scotland and England.

TABLE OF THE DIVISIONS OF BRITISH CARBONIFEROUS ROCKS.			TYPICAL AREAS.	
			SCOTLAND.	ENGLAND.
Upper Carboniferous.	Coal-Measures.	Upper Coal-Measures.	Presence uncertain.	Parts of Somerset Coal Field and South Wales Coal Field; the whole of the Forest of Dean Coal Field.
		Transition Series.	Absent.	Parts of Somerset Coal Field (New Rock and Vobster Series), and South Wales Coal Field (Lower Pennant Rock).
		Middle Coal-Measures.	Red shales and sandstones of Fife, etc. The d$^{6'}$ of the Geological Survey of Scotland.	Parts of South Staffordshire Coal Field; the Coal Field of the Potteries, North Staffordshire; Lancashire Coal Field; and Yorkshire Coal Field.
		Lower Coal-Measures.	The "Flat Coals" of Scotland. Stirlingshire, Lanarkshire, and Ayrshire Coal Fields, etc. All "Coal-Measure" Coals in Scotland belong to this division. The d^{5} of the Geological Survey of Scotland.	Parts of Potteries Coal Field, North Staffordshire; Yorkshire Coal Field; and Northumberland Coal Field.
	Millstone Grit Series.		Present, various coal fields, etc.	Present, various coal fields, etc.
Lower Carboniferous.	Carboniferous Limestone Series (Scotland (=Yoredale Rocks of England).		Centre of Scotland. The coals in this series are distinguished as the "Edge Coals."	Yorkshire, Westmoreland, Cumberland, and Northumberland.
	Calciferous Sandstone Series (Scotland) (=Mountain Limestone of England).		Centre and South of Scotland.	Northumberland, Flintshire, and North Cumberland (Calciferous Sandstone Series type). Large areas in North-west of England (Mountain Limestone type).
Upper Old Red Sandstone.				

NOTES ON THE FLORA OF THE VARIOUS DIVISIONS OF BRITISH CARBONIFEROUS ROCKS.

LOWER CARBONIFEROUS.

General Remarks.—The flora of the Lower Carboniferous is much more scanty than that of Upper Carboniferous rocks.

The prevailing species is *Lepidodendron Veltheimianum*, Sternb., which is most abundant, and occurs in all conditions of growth and age. The genus *Sigillaria* is much less frequent. *Lepidophloios* also is present. The ferns are generally characterised by having more or less distinctly cuneate or very narrow linear pinnules, in distinction to the round-lappeted pinnules of the majority of Upper Carboniferous ferns. *Asterocalamites* is distributed throughout the whole of the Lower Carboniferous, but *Calamites* is extremely rare, only two specimens of this genus having yet come under my notice from rocks of this age.

I. CALCIFEROUS SANDSTONE SERIES.

The two most characteristic ferns of the Calciferous Sandstone Series are *Calymmatotheca affinis*, L. and H. sp., and *Calymmatotheca bifida*, L. and H. sp. These are frequent in their occurrence, and not restricted to any particular bed.

The following ferns, though much less common, have hitherto also only been found in this series:—*Alcicornopteris convoluta*, Kidston, *Adiantides antiquus*, Ett. sp., *Rhacopteris flabellata*, Tate sp., *Rhacopteris Geikiei*, Kidston, *Rhacopteris subcuneata*, Kidston, *Sphenopteris pachyrrachis*, Göpp., *Sphen. subgeniculata*, Stur sp., *Sphen. Macconochii*, Kidston sp., *Sphen. Teiliana*, Kidston, *Sphen. Machanekii*, Ett. sp., *Sphen. Moravica*, Ett. sp., *Sphen. Hochstetteri*, Stur sp., and *Caulopteris minuta*, Kidston.

Among the Lycopods *Lepidodendron Volkmannianum*, Sternb., and *Lepidostrobus fimbriatus*, also appear to be restricted to this horizon.

The only *Sigillaria* occurring in this series is the *S. Taylori*, Carr. sp., which, however, is comparatively common,—especially in the oil shales. From the cement-stone group two species of *Lycopodites*—*L. Vanuxemi*, Göpp. sp., and *L. Stockii*, Kidston, have also been got.

The Calciferous sandstones have yielded four species of *Bythotrephis*, which have not yet been found elsewhere, and one of *Ptilophyton*—*P. plumula*, Dawson.

The Calciferous Sandstone Series therefore possesses a distinctive flora, which, though allied to that of the overlying Carboniferous Limestone Series, possesses individual features, which admit of its easy separation from the latter series.

II. CARBONIFEROUS LIMESTONE SERIES.

This series is distinguished by its fossil plants from the underlying Calciferous Sandstone Series,—as much by the absence of many species that occur in the underlying rocks as by the presence of a number of plants characteristic of itself.

Notwithstanding the great development of coal in the Carboniferous Limestone Series, fossil plants are much more rare than in the Calciferous Sandstone Series.

Again, in the Carboniferous Limestone Series, the prevailing plant is *Lepidodendron Veltheimianum*, Sternb.; *Sigillaria Taylori*, Carr. sp., also occurs, but more rarely. From it has been got the only specimen of a ribbed *Sigillaria*—*S. Youngiana*, Kidston—which has yet been met with in British Lower Carboniferous rocks.

The Carboniferous Limestone Series contains some beds composed almost entirely of the curious Alga, *Spirophyton Cauda-galli*, Vanuxem sp., entangled among whose fronds are found joints of encrinites.

Among the ferns *Sphen. Dicksonioides*, Göpp., *Sphen. Linkii*, Göpp. sp., *Sphen. Haueri*, Stur, *Sphen. Gersdorfii*, Göpp. sp., *Adiantides Machanekii*, Stur, and *Archæopteris Tschermaki*, Stur, appear to be peculiar to this group.

Volkmannia Morrisii, Hooker, has also only been found in these rocks.

UPPER CARBONIFEROUS.

III. MILLSTONE GRIT.

Fossil plants are very rare in rocks of this age. The specimens found in the sandstones are generally too imperfectly preserved to admit of satisfactory determination, and the associated shales are most frequently barren. All the species yet discovered in this series are identical with those occurring in the Lower Coal-Measures—in fact, so far as one can learn from the fossil plants, the Millstone Grit does not palæontologically form a separate series.

During the deposition of these rocks the physical conditions must have differed somewhat from those which existed during the formation of the Coal-Measures, but the plant life which plays such an important part in the formation of coal in the Coal-Measures, here makes its appearance upon the scene. It has already been mentioned that the plants whose advent takes place in the Millstone Grit, are all specifically distinct from those which preceded them, and that we here meet with a new flora—a flora having a *facies* of its own, and whose general characteristics are common to the plants of the succeeding Coal-Measures.

COAL-MEASURES.

The Coal-Measures are characterised by a great development of *Ferns*, *Calamites*, *Lepidodendra*, *Sigillariæ*, and *Cordaites*, but in each of the divisions of the Coal-Measures —the Lower, the Middle, and the Upper—certain groups are more developed in one division than in the others.

IV. LOWER COAL-MEASURES.

The most common plants of the Lower Coal-Measures are *Neuropteris heterophylla*, Brongt., *Alethopteris lonchitica*, Schl. sp., *Aleth. decurrens*, Artis sp., *Sphen. obtusiloba*, Brongt., *Lepidodendron ophiurus*, Brongt., *Calamites Suckowii*, Brongt., and *Calamites ramosus*, Artis.

Many other species of these genera occur, but the above, from their quantity and general distribution, may be regarded as characteristic of the series.

Sigillaria, though represented by a number of species, is nowhere very common — the most frequently met with representatives of the genus being *Sigillaria discophora*, König sp., and *Sig. scutellata*, Brongt.

It is true that every one of these species occurs in the Middle Coal-Measures, and that all are even more or less common there; but in the Middle Coal-Measures they are associated with a great many other species, which are almost entirely unknown in the Lower Coal-Measures.

The great distinguishing point then, between the Lower and Middle Coal-Measures, is not that the Lower Coal-Measures are characterised so much by a flora peculiar to itself, but by the absence of so many of the species which occur in the Middle Coal-Measures, and which give to this later series so distinguishing a character.

It must be remarked, however, that the Lower Coal-Measures possess several species apparently peculiar to itself, such as *Sphen. adiantoides*, L. and H., *Sphyropteris Boehmischi*, Stur, *Neuropteris rectinervis*, Kidston, *Neur. Blissii*, Lesqx., *Neur. crenulata*, Brongt., *Stachannularia Northumbriana*, Kidston, *Lepidodendron serpentigerum*, König, *Sigillaria Walchii*, Sauveur, *Psygmophyllum flabellatum*, L. and H. sp., etc.; but all these are more or less rare, and several of them only known from one or two localities; and it is not so much on their presence that the distinguishing feature of the Lower Coal-Measure flora depends as on the absence of so many species that are common in the Middle Coal-Measures.

Large tree-fern stems first appear in the Lower Coal-Measures, and are represented by *Megaphyton frondosum*, Artis, and *Megaphyton approximatum*, L. and H. They are, however, extremely rare.

The flora of the Lower Coal-Measures, though much richer than that of the two series composing the Lower Carboniferous, did not attain to the same development as we meet with in the Middle Coal-Measures, where, perhaps, there is even a richer flora than that found in the Upper Coal-Measures.

V. MIDDLE COAL-MEASURES.

As already pointed out, the Middle Coal-Measures are distinguished from the Lower Coal-Measures by their much richer flora. All the commoner species of the Lower Coal-Measures occur here, but in addition many more which are not found in any other horizon, and it is these which so fully characterise the Middle Coal-Measures, and make its separation from either the Upper or the Lower Coal-Measures so easy.

The genus *Sphenopteris* here attains its maximum development, and is represented by many species which appear to be only found in Britain in these rocks. Of these may be mentioned *Sphenopteris grandifrons*, Sauv., *Sphen. Sauveuri*, Crépin, *Sphen. Marratii*, Kidston, *Sphen. rotundifolia*, Andræ, *Sphen. mixta*, Schimper, *Sphen. coriacea*, Marrat, *Sphen. Jacquoti*, Zeiller sp., *Sphen. flexuosa*, Gutbier, and *Sphen. trifoliolata*, Artis sp., which last, though it has been found very rarely in the Lower Coal-Measures, is a most characteristic plant of the series. Other ferns also peculiar to these rocks are—*Hymenophyllites quadridachylites*, Gutbier sp., *Oligocarpia Brongniarti*, Stur, *Archæopteris Reussii*, Ett. sp., *Calymmatotheca asteroides*, Lesqx., *Sphyropteris obliqua*, Marrat sp., *Hymenotheca Dathei*, Potomie, *Zeilleria Avoldensis*, Stur sp., *Zeilleria delicatula*, Sternb. sp., *Alethopteris valida*, Boulay, *Lonchopteris rugosa*, Brongt., and *Lonchopteris Bricii*, Brongt. *Odontopteris* and *Neuropteris* are also represented by a greater number of species than in any other horizon. Of these genera, *Odontopteris Britannica*, Gutbier, *O. Reichiana*, Gutbier, and *O. Coemansii*, Andræ, and *Neuropteris tenuifolia*, Schl. sp., *N. Grangeri*, Brongt., *N. obliqua*, Brongt. sp., *N. Elrodi*, Lesqx., *N. microphylla*, Brongt., *N. plicata*, Sternb., *N. Osmundæ*, Artis sp., and *N. Schlehani*, Stur, appear to be restricted to the Middle Coal-Measures.

From this series has been got the only specimens of *Equisetum* (*E. Hemingwayi*, Kidston) which I have yet met with in British Carboniferous rocks, though MM. Renault and Zeiller record the genus from the Upper Coal-Measures of Comentry, France.[1]

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[1] See Comptes Rendus, Paris, January 5, 1885; also Études sur le terr. houil. d. Comentry: Flore fossile, part ii., p. 394, pl. lvii., fig. 7 (Bull. de la Soc. de l'industrie minérale, 3e sér., vol. iv., II.e livr., 1890, St Étienne).

The *Calamarieæ* are strongly represented, but contain few species peculiar to the series. The same remark may be made in connection with the genus *Sphenophyllum*. The *Lepidodendra* here hold about the same position in regard to species and their frequency of occurrence that they do in the Lower Coal-Measures, *Lepidodendron ophiurus*, Brongt., being also here the species most commonly met with.

The genus *Lepidophloios* is not very common. *Lepidophloios laricinus*, Sternb. sp., has only been found in this horizon in Britain, and it is rare. *Lepidophloios acerosus*, L. and H. sp., is, however, more frequent.

In the Middle Coal-Measures the genus *Sigillaria* attains its maximum state of development, and is represented by many species, a number of which are peculiar to these rocks, and many of those which occur in other horizons are generally more plentiful here than elsewhere. Some of those which appear to be peculiar to the Middle Coal-Measures are *Sig. polyploca*, Boulay, *Sig. elongata*, Brongt., *Sig. Deutschiana*, Brongt., *Sig. Saulii*, Brongt., and *Sig. cordigera*, Zeiller.

Cordaites is frequent. The most common species here, as in the Lower Coal-Measures, is *Cordaites principalis*, Germar sp.

As far as our investigations have yet gone, the Middle Coal-Measures would appear to have possessed a richer flora than any of the other divisions of the Carboniferous formation—certainly a richer flora than that occurring in the Lower Coal-Measures; but further investigations are necessary before final conclusions on this point are warranted.

VI. TRANSITION SERIES.

Typical Area—Lower Pennant Rocks of the South Wales Coal Field.

This series, as its name indicates, is particularised by an almost equal mixture of the species which are characteristic of the rocks on which it rests and of those which overlie it.

So far as our work has gone, the only series in the Coal-Measures necessitating the use of the term "*Transition*" met with, lies between the Middle and Upper Coal-Measures.

This series is well shown in the South Wales Coal Field, where the Lower Pennant Rocks, and in Somerset the New Rock and Vobster Series, belong to it.

In the coal field of the Potteries the dividing line between the Middle and Upper Coal-Measures has been drawn at a thin band of *Spirorbis* Limestone. There seems to be no break between the two series, and the division between them is an arbitrary one.

In the rocks a few yards above the *Spirorbis* Limestone, Dr Hind has met with *Neur. heterophylla*, Brongt., and *Neur. gigantea*, Sternb., along with *Sphenophyllum emarginatum*, Brongt. The two first species are characteristic of Middle and Lower Coal-Measures, and the last mentioned of Upper Coal-Measure rocks. Some other species were collected from the same bed, but were too imperfect to admit of a satisfactory determination.

The rocks in the region of this *Spirorbis* Limestone are clearly of a "*Transition Series*" nature, but in the Potteries Coal Field they appear to be so feebly developed that for practical purposes they do not need, and, in fact, can scarcely be, separated from the overlying Upper Coal-Measures with which they have been classed. But it is desirable to mention these facts here.

In the same coal field there appear to be indications of a *Transition Series* between the Lower and Middle Coal-Measures, but they are so slightly developed as to demand no further notice than the mere mention of the circumstance.

It is unnecessary to particularly mention the plants which characterise this series, for its character is simply an admixture of Middle and Upper Coal-Measure species. This is shown in the column devoted to the flora of the Transition Series, which is given in the "Vertical Distribution Tables" at the end of this address.

VII. UPPER COAL-MEASURES.

The outstanding plants by which the Upper Coal-Measures are distinguished from all the other horizons are the various species of the genus *Pecopteris*—those species which belong to the *Cyatheites* group of Göppert.

In British Upper Coal-Measures these ferns are represented by *Pec. arborescens*, Schl. sp., and var. *cyathea*, Brongt. sp., *Pec. oreopteridia*, Schl. sp., *Pec. Cistii*, Brongt., *Pec. Bucklandii*, Brongt., *Pec. pteroides*, Brongt., *Pec. crenulata*, Brongt., *Pec. pinnatifida*, Gutbier sp., *Pec. Lamuriana*, Heer, *Pec. polymorpha*, Brongt., *Pec. Candolliana*, Brongt., *Pec. unita*, Brongt., and *forma emarginata*, Göpp. sp.

None of these have been found out of this series. *Pec. Miltoni*, Artis sp. (= *Pec. abbreviata*, Brongt.), also occurs plentifully, but it is likewise met with in the Middle Coal-Measures.

Several of these ferns are very common in this series—especially *Pec. arborescens*, Schl. sp., and var. *cyathea*, *Pec. oreopteridia*, Schl. sp., and *Pec. unita*, Brongt.

This group of ferns is enough in itself to distinguish the Upper from the other series of the Coal-Measures, and they impart to these rocks a very distinct botanical *facies*. In the Radstock and Farrington Series, Somerset, it is almost impossible to split a block of shale—locally called "*greys*"—without finding traces of one or other of these Pecopterids. They outnumber in quantity all the other plants there met with.

Another extremely common fern in the Upper Coal-Measures is *Alethopteris Serlii*, Brongt. sp. Individually this is perhaps the commonest species of all, and occurs in great numbers, and though one of the most characteristic plants of the Upper Coal-Measures, it occurs, though very rarely, in the Middle Coal-Measures.

Among other ferns which appear to be restricted to the Upper Coal-Measures are *Sphen. macilenta*, L. and H., *Sphen. tenuifolia* (Brongt.), Gutbier, *Sphen. Woodwardii*, Kidston, *Corynepteris erosa*, Gutbier sp., *Unatheca oblonga*, Kidston, *Dicksoniites Pluckenetii*, Schl. sp., *Alethopteris Grandini*, Brongt. sp., *Desmopteris longifolia*, Presl. sp., *Odontopteris Lindleyana*, Sternb., *Neur. ovata*, Hoffm., and *Neur. flexuosa*, Brongt. The last is common, and *Neur. ovata* is frequent.

Several species of *Rhacophyllum* are also met with. Some of these may be only *Aphlebia*, which were attached to the rachis of other species; but others, such as *R. Goldenbergii*, Weiss, and *R. spinulosum*, Lesqx., evidently form autonomous species.

Tree ferns, though they first appear in the Lower Coal-Measures, here attain their maximum development, and are represented by several species.

Calamites are much less frequent than in the Middle and Lower Coal-Measures, and appear to be dying out. *Annularia* is represented by *Annularia stellata*, Schl. sp., and *Annularia sphenophylloides*, Zenker sp., both of which are common, especially the latter.

Sphenophyllum emarginatum, Brongt., is very common, and with the exception of *Sphenophyllum majus*, Bronn., which is very rare, is the only member of the genus met with in these rocks.

The *Lepidodendra*, like the *Calamites*, become rare. Some of the more prevalent and common genera of the Middle and Lower Coal-Measures are clearly dying out in the Upper Coal-Measures, and though still represented by several species, in the majority of cases they are rare. *Lepidodendron lanceolatum*, Lesqx., and *Lepidodendron Wortheni*, Lesqx., are the two most common, but neither form a feature of the flora.

Lepidophloios has all but disappeared. I have only seen one imperfectly preserved specimen in the Upper Coal-Measures, which, unfortunately, I could not determine. The genus *Bothrodendron* has evidently died out.

Sigillaria, though still represented by several species, possesses only one which is common — *Sigillaria tesselata*, Brongt., and the form that occurs is scarcely typical of the species. Only one species—*Sigillaria M'Murtriei*, Kidston —seems to be peculiar to the series.

A single specimen of *Lycopodites elongatus*, Gold., has been collected from this horizon by Mr Hemingway.

The *Cordaites* are represented by only two species, one of which—*Cordaites angulosostriatus*, Grand' Eury—is common, and may be regarded as a typical plant for this horizon. *Poacordaites microstachys*, Gold., also occurs, but is infrequent.

The only clear evidence of the presence of *Coniferæ* which I have met with in British Carboniferous rocks (with the exception of one or two small seeds of a *Gnetopsis*, Ren. and Zeiller, collected by Mr Hemingway from the Middle Coal-Measures of Yorkshire) is that afforded by a small specimen of *Walchia imbricata*, Schimper, which was found in the Upper Coal-Measures when sinking the shaft of the Hamstead Colliery, Great Barr, near Birmingham.[1]

These notes on the flora of the Upper Coal-Measures will show that the plants of that series were of a very distinctive type.

It may be mentioned here that in France there is a higher series of Upper Coal-Measures than any found in Britain, where it would appear that rocks on the horizon of our Upper Coal-Measures are entirely absent.

EXPLANATORY NOTES ON THE TABLE OF DISTRIBUTION OF SPECIES.

Although each series of the Coal-Measures is distinctly characterised by its own flora, there are many species which are common to more than one series, and some even extend throughout the whole of the Upper Carboniferous. Of these species some are equally common in two of the series, but are very seldom, if ever (except in the case of *Stigmaria*), equally common in all.

The lists given in the table showing the distribution of the fossil plants in the Carboniferous rocks of Britain do not bring out this relative proportion of the species in the different series, but it is represented diagramatically in the case of some of the more widely—in time—extending species in the following table :—

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[1] Trans. Roy. Soc. Edin., vol. xxxv., part 6, p. 324, fig. 9.

	UPPER CARBONIFEROUS.					PERMIAN.
	Millstone Grit.	Lower Coal-Measures.	Middle Coal-Measures.	Transition Series.	Upper Coal-Measures.	
Pecopteris arborescens, Schl. sp.					█	—
Marcopteris muricata, Schl. sp.	▬	█	█	⋯	▬	
Alethopteris lonchitica, Schl. sp.		█	█	⋯	—	
,, *decurrens*, Artis sp.		█	█	⋯	—	
,, *Serlii*, Brongt. sp.			—	▬	█	
Neuropteris heterophylla, Brongt.		█	█	—		
,, *gigantea*, Sternb.		█	█	—		
,, *rarinervis*, Bunbury.			▬	▬	▬	
,, *Scheuchzeri*, Hoffm.			▬	▬	█	
Calamitina undulata, Sternb. sp.		█	█	⋯	—	
Calamites ramosus, Artis.		█	█	⋯	▬	
,, *Suckowii*, Brongt.	█	█	█	⋯	▬	
,, *Cistii*, Brongt.		▬	▬	—	—	
Annularia sphenophylloides, Zenker sp.			—	—	█	—
Lepidodendron aculeatum, Sternb.	▬	█	█	⋯	▬	
Sigillaria discophora, König. sp.	▬	█	█	⋯	—	
,, *tessellata*, Brongt.		—	█	█	█	
Stigmaria ficoides, Sternb. sp.	█	█	█	█	█	▬
Cordaites borassifolius, Sternb. sp.		—	▬	⋯	—	
,, *angulosostriatus*, Grand'Eury.				—	█	—

It must not be understood that the tables appended to this communication give a complete list of the fossil plants occurring in British Carboniferous rocks.

In a branch of palæontology where so much yet remains to be done, many species will yet, undoubtedly, be added to the flora of these rocks. In my own hands is still a number of species: some of these, though too imperfectly preserved for a satisfactory determination, are sufficiently perfect to show that they are specifically different from any mentioned in my lists; others await more careful examination, and some are apparently undescribed.

I have also omitted from the lists all doubtful species—

species founded on imperfectly preserved material,—the types of which in the great majority of cases are lost, and of which, even with the figures that accompany their description, there is not sufficient data to enable one to recognise again the plants which have been intended.[1]

The addition of such doubtful species to the lists would not give any further insight into the Carboniferous flora, and would only hamper the subject with barren names.

Although I have taken every means in my power to accurately ascertain the horizons from which the fossils came, mistakes may have crept in, as the evidence has been collected from so many sources; but in all cases where I saw any reasonable cause for doubt, no record has been made of the species.

Neither do I claim infallibility in my identifications, though I have taken every care to obtain accuracy in this respect; still, when one considers the many thousands of specimens which must have passed under my examination, it is quite possible that some slips may have occurred. But even admitting this, I feel confident that there are no errors which in any way vitiate the general conclusions arrived at as to the value of fossil plants in distinguishing the different series of the Carboniferous formation which are accepted in this address.

It is not my intention to enter into the question of the affinities of the plants with which we have been dealing. The subject is too large a one to go fully into at present, but before concluding, I wish to make a few short remarks on this subject.

I am afraid that we must give up several of our old ideas of the ancestry of some of the existing genera.

One used to be taught that the humble club-mosses which grow on our hills and moors, and the horsetails (*Equisetum*) that garnish our lochs and river shallows, were the depauperised descendants of the *Lepidodendra* and *Calamites* respectively.

I am sorry to say that my faith in this beautiful ancestral pedigree has been rudely shaken, and I am, further, afraid that I may be thought very heterodox in the opinions I am now inclined to hold as to the ancestry of our club-mosses and horsetails.

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[1] See list of some of these, Proc. Roy. Phys. Soc., vol. x., 1891, p. 390. It is possible, however, that some of these may yet be identified.

When we find in Carboniferous times certain fossils (some of which are included in my list under the name of *Lycopodites*, Goldenberg, not Brongt.), which, *so far as one can observe*, do not differ either in their manner of growth, foliage, or mode of fructification from recent Lycopods, and which some authors have boldly classed with *Lycopodium*, I am afraid, then, we can no longer indulge in the supposed noble ancestry of our little Lycopods, but must accept the fact that they most probably are descended, with little alteration, from comparatively humble plants which never attained to arborescent dimensions.

Lepidodendron, *Bothrodendron*, and *Sigillaria* appear to be genera which have passed away without having transmitted to us any posterity, even in a depauperated condition.

As to the *Calamites*, I am here again afraid we must discard our old idea of their being the ancestors of our existing *Equisetum*.

The genus *Equisetum* seems to have existed in Carboniferous times; whatever its ancestor was, by that time its earlier progenitor had apparently died out. The *Equisetum* of palæozoic times, however, seems to have been somewhat larger than any of the recent species, though it does not appear to have attained to gigantic dimensions, even in those far-back days.

Calamites seem to have entirely disappeared, but the genus *Calamites*, as generally employed, is really more than a genus —it contains a group of plants, the fructification of which, though possessed of certain common structural characters, differed in many points, as in the mode of attachment of, and the position of the sporangia to the bracts and the axis of the cone. These differences are such, that, according to our modern ideas of classification, it would be impossible to place in one genus plants whose fructification differed in so many structural details.

There is one more picture of our youth to which I wish to refer, and I am done.

We were taught to believe that the low-lying ground of

Carboniferous times, intersected by lagoons and swamps, was clothed with a dense growth of *Lepidodendra*, *Sigillariæ*, *Calamites*, and ferns, and the distant hills (which somehow or other never seemed to be very far away) were covered with primæval forests of pine. Sometimes a restored view was produced which vividly portrayed all these features, and which was generally further embellished by the addition of some living creatures in the foreground and plenty of fumaroles giving off vapour, wherever space could be found for them in the picture.

Now as to the *Lepidodendra*, *Sigillariæ*, *Calamites*, and ferns, I have little to say. Almost certainly many of these occupied low-lying swampy situations—but to the background of pines I must entirely dissent.

When we know that *Araucarioxylon Brandlingii* is the wood of *Cordaites*, on what form of argument can we any longer base our belief that the other large stems put in that genus or in *Dadoxylon*, belonged to a different class of plants?

In all the divisions of the Carboniferous formation where these large so-called *Araucarioxylon* trunks have been found, we also get *Cordaites* leaves, but never any traces of Coniferous trees, which surely would have been met with had they existed. I can see little reason to doubt that the other *Araucarioxylon* stems are also the trunks of *Cordaites*.

It is rather curious that the first trace of true Coniferæ which has been met with in Britain, was a small specimen of *Walchia imbricata*, Schimper, from the Upper Coal-Measures, where, strangely enough, none of these large trunks have been found; but if we grant that these large trunks were the stems of *Cordaites*, they must have existed at that time also, for *Cordaites* is frequent in the Upper Coal-Measures. *Cordaites*, though gymnospermous, cannot be classed with any existing group.

To return to our picture again, I would suggest that the pines on the hills should be replaced by *Cordaites*, and further, that these should be transplanted from the high ground to the low-lying tracts, leaving the ideal hills for the occupation of more ideal tenants.

I cannot conclude without acknowledging my great indebtedness to numerous friends who have willingly helped me in my studies of the flora of the Carboniferous period, and without whose aid my knowledge of the flora of this period must have been very much more imperfect than it is. Even with all their kind assistance, I am just beginning to know how much there is still to learn about our Carboniferous plants, but I hope that my friends will continue to afford me what help they can, as there is much work yet to be done in this interesting field of palæontology.

Note.—I am frequently asked where good figures of the British Carboniferous flora can be found. An answer to this question would entail a long list of the literature of the subject, which is scattered through the *Transactions* of numerous scientific societies, as well as contained in many volumes specially devoted to this subject.

But good figures of the more typical species will be found in Brongniart's "Histoire des végétaux fossiles" and Zeiller's "Flore fossile du Bassin houiller de Valenciennes," the latter being specially excellent for Middle and Lower Coal-Measure Species. For the Lower Carboniferous flora, the most complete work is Stur's "Culm Flora," though it does not contain all the British species. Many other useful works might be mentioned, but references to many of these will be found in the works of Zeiller and Stur mentioned above.

TABLE SHOWING THE VERTICAL DISTRIBUTION OF CARBONIFEROUS PLANTS IN BRITAIN.

NAME.	GENERAL DISTRIBUTION.							LOWER CARBONIFEROUS.				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.						
	COAL-MEASURES.							SCOTLAND.		ENGLAND.		
	Upper Coal-Measures.	Transition Series.	Middle Coal-Measures.	Lower Coal-Measures.	Millstone Grit.	Carboniferous Limestone Series, Scotland =Yoredale Rocks, England.	Calciferous Sandstone Series, Scotland =Mountain Limestone, England.	Carboniferous Limestone Series.	Calciferous Sandstone Series.	Yoredale Rocks.	Mountain Limestone.	
FUNGI.												
Excipulites, Göpp., 1836, . . . *callipteridis*, Schimper sp.,[1] .	×											[1] On *Sphenopteris neuropteroides*, Boulay sp.
ALGÆ.												
Spirophyton, Hall, 1863, . . . *Cauda-galli*, Vanux. sp., . .						×		×				[2] *bis* I have used this genus in a general by placing in it all the palæozoic

Ptilophyton, Dawson, 1878,											
plumula, Dawson,[2]							×		×		×
FILICACEÆ.											
SPHENOPTERIDEÆ.											
Sphenopteris, Brongniart, 1822,											
obtusiloba, Brongt.,			×	×							
dilatata, L. and H.,			×	×							
trifoliolata, Artis sp.,			×	×							
polyphylla, L. and H.,[3]			?								
nummularia, Gutbier,			×	×							
grandifrons, Sauveur,			×								
Sauveuri, Crépin,			×								
Marratii, Kidston,			×								
neuropteroides, Boulay sp.,	×	×									
adiantoides, L. and H.,				×							
Schillingsii, Andræ,[4]				×							
macilenta, L. and H.,	×										
latifolia, Brongt.,			×	×							
acuta, Brongt.,			×	×							
Conwayi, L. and H.,			×								
Höninghausi, Brongt.,			×	×							
Dicksonioides, Göpp.,						×	×	×			×
decomposita, Kidston,							×		×		×
Dunsii, Kidston,[5]							×		×		
amœna, Stur sp.,				×							
Laurentii, Andræ,			×	×							
rotundifolia, Andræ,			×								
cristata, Brongt. sp.,	×		×								
mixta, Schimper,			×								
coriacea, Marrat,			×								

Algæ.

[2] Dawson thinks this genus may be allied to Lycopods and Pillworts, but its more natural place seems to me to be among the Algæ, though its true position is uncertain. *Geol. Survey of Canada*—"Fossil Plants of Erian (Devon.) and Upper Silur. Forms," part ii., 1882, p. 122.

[3] The exact horizon of this species cannot be ascertained at present. But there is a strong reason to believe it came from the Middle Coal-Measures. The only specimen I have seen is the type which is preserved in the collection of the Geological Society, London.

[4] I am somewhat doubtful if this is specifically distinct from *Sphen. adiantoides*, L. and H.

[5] For description see following communication, p. 259, pl. iv., figs. 1-4.

TABLE SHOWING THE VERTICAL DISTRIBUTION OF CARBONIFEROUS PLANTS IN BRITAIN.

NAME.	GENERAL DISTRIBUTION.							LOWER CARBONIFEROUS.				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.		SCOTLAND.		ENGLAND.		
	COAL-MEASURES.											
	Upper Coal-Measures.	Transition Series.	Middle Coal-Measures.	Lower Coal-Measures.	Millstone Grit.	Carboniferous Limestone Series, Scotland =Yoredale Rocks, England.	Calciferous Sandstone Series, Scotland =Mountain Limestone, England.	Carboniferous Limestone Series.	Calciferous Sandstone Series.	Yoredale Rocks.	Mountain Limestone.	
FUNGI.												
Excipulites, Göpp., 1836, . . .												[1] On *Sphenopteris neuropteroides*, Boulay sp.
callipteridis, Schimper sp.,[1] .	×											
ALGÆ.												
Spirophyton, Hall, 1863, . . .												
Cauda-galli, Vanux. sp., . .						×		×				
Bythotrephis, Hall, 1847,[2 bis] . .												[2 bis] I have used this genus in a general sense by placing in it all the palæozoic Algæ met with, except *Spirophyton* and *Ptilophyton*. As we know nothing
Scotica, Kidston, . . .							×		×			
Worstonensis, Kidston, . .							×				×	
simplex, Kidston sp., . .							×		×			

plumosus, Kidston sp.,							×		×		×
acicularis, Göpp. sp.,							×		×		
Ptilophyton, Dawson, 1878,											
plumula, Dawson,[2]							×		×		×
FILICACEÆ.											
SPHENOPTERIDEÆ.											
Sphenopteris, Brongniart, 1822,											
obtusiloba, Brongt.,			×	×							
dilatata, L. and H.,			×	×							
trifoliolata, Artis sp.,			×	×							
polyphylla, L. and H.,[3]			?								
nummularia, Gutbier,			×	×							
grandifrons, Sauveur,			×								
Sauveuri, Crépin,			×								
Marratii, Kidston,			×								
neuropteroides, Boulay sp.,	×	×									
adiantoides, L. and H.,				×							
Schillingsii, Andræ,[4]				×							
macilenta, L. and H.,	×										
latifolia, Brongt.,			×	×							
acuta, Brongt.,			×	×							
Conwayi, L. and H.,			×								
Höninghausi, Brongt.,			×	×							
Dicksonioides, Göpp.,						×	×	×			×
decomposita, Kidston,							×		×		×
Dunsii, Kidston,[5]							×		×		
amœna, Stur sp.,				×							
Laurentii, Andræ,			×	×							
rotundifolia, Andræ,			×								
cristata, Brongt. sp.,	×		×								
mixta, Schimper,			×								
coriacea, Marrat,			×								

of the relationship of these fossils to recent species, this course is generally adopted in dealing with palæozoic Algæ.

[2] Dawson thinks this genus may be allied to Lycopods and Pillworts, but its more natural place seems to me to be among the Algæ, though its true position is uncertain. *Geol. Survey of Canada*—"Fossil Plants of Erian (Devon.) and Upper Silur. Forms," part ii., 1882, p. 122.

[3] The exact horizon of this species cannot be ascertained at present. But there is a strong reason to believe it came from the Middle Coal-Measures. The only specimen I have seen is the type which is preserved in the collection of the Geological Society, London.

[4] I am somewhat doubtful if this is specifically distinct from *Sphen. adiantoides*, L. and H.

[5] For description see following communication, p. 259, pl. iv., figs. 1-4.

NAME.	GENERAL DISTRIBUTION.							LOWER CARBONIFEROUS.				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.		SCOTLAND.		ENGLAND.		
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand.	Carb. Lime.	Calcif. Sand.	Yoredale.	Mountain.	
Sphenopteris—continued.												
Jacquoti, Zeiller sp.,			×									
tenuifolia (Brongt.) Gutbier,	×											
effusa, Kidston,				?								
Woodwardii, Kidston,	×											
Linkii, Göpp. sp.,						×		×				
Hibberti, L. and H.,						×	×	×	×			
excelsa, L. and H.,							×		×			
Ettingshauseni, Feistm.,						×	×	×	×			
Haueri, Stur,						×		×				
crassa, L. and H.,						×	×	×	×			
pachyrrachis, Göpp,							×		×		×	
,, var. *stenophylla*, Göpp.							×		×		×	
Zobelli, Göpp.,			×	×								
Macconochii, Kidston sp.,							×		×			
spinosa, Göpp.,			×	×								
spiniformis, Kidston,[1]			×									[1] See *Trans. Yorkshire Nat. Union*, part xviii., 1893, p. 103.
Sternbergii, Ett. sp.,			×	×								
furcata, Brongt.,			×	×								
flexuosa, Gutbier,			×									
Grandini, Göpp. sp.,	×											
geniculata, Germ. and Kaulf.,	×											
subgeniculata, Stur sp.,							×		×		×	
elegans, Brongt.,						×	×	×	×			
dissecta, Brongt.,			×	×								

Teiliana, Kidston, . . .					×			×
Machanekii, Ett. sp., . . .					×		×	
multifida, L. and H., . .		×						
Gersdorfii, Göpp. sp., . .				×		×		
Moravica, Ett. sp., . . .					×		×	
Hochstetteri, Stur sp., . .					×		×	
Sphenopteridium, Schimper, 1874, .								
dissectum, Göpp. sp., . . .				×	×	×	×	
Eremopteris, Schimper, 1869, . .								
artemisiæfolia, Sternb. sp., .		×	×					
Rhacopteris, Schimper, 1869, . .								
inæquilatera, Göpp., sp., . .				×	×	×	×	×
dubia, L. and H. sp., . .		?						
flabellata, Tate sp., . . .					×		×	×
(?) *petiolata*, Göpp., . . .				×		×		
transitionis, Stur, . . .				×	×	×	×	
Geikiei, Kidston, . . .					×		×	
subcuneata, Kidston,[2] . .					×			×
Adiantides, Schimper, 1869, . .								
antiquus, Ett. sp., . . .					×		×	×
Machanekii, Stur, . . .				×		×		
(?) *oblongifolius*, Göpp., . .					×		×	
Macrosphenopteris, Kidston, 1888, .								
Lindsæoides, Kidston, . .	×							
Hymenophyllites, Göpp., 1836, . .								
quadridactylites, Gutbier sp., .		×						
Oligocarpia, Göpp., 1841, . . .								
Brongniarti, Stur, . . .		×						

[2] For description see following communication, p. 261, pl. v., fig. 2; pl. vi., fig. 1.

NAME.	GENERAL DISTRIBUTIC							CA				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.		SCOTLAND.		ENGLAND.		
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand	Carb. Lime.	Calcif. Sand.	Yoredale.	Mountain.	
Schizostachys, Grand' Eury, 1877,												
sphenopteroides, Kidston,	×											
Corynepteris, Baily, 1860,												
erosa, Gutbier sp.,	×											
coralloides, Gutbier sp.,			×									
Renaultia, Zeiller, 1883,												
microcarpa, Lesqx. sp.,				×								*phenopterisgracilis*, Brongt., "Hist. d. végét. foss.," p. 197, pl. liv., fig. 3. If the fern described and figured by Zeiller in his "Flore foss. d. bassin houil. de Valenciennes," p. 94, pl. iv., figs. 2 and 3, as *Renaultia gracilis*, Brongt. sp., is really that plant, then *R. Footneri*, Marrat sp., must be reduced to a synonym of Brongniart's species. *Renaultia Footneri* occurs on the same horizon as *Renaultia* (*Sphen.*) *gracilis*, Brongt., but I have not yet clearly satisfied myself that the plants are identical,—possibly they are, however. Unless this is the case, I have not yet seen *Sphen. gracilis*, Brongt., in Britain.
Footneri, Marrat sp.,			×	×								
gracilis, Brongt. sp.,[1]				×								
Schatzlarensis, Stur sp.,			×	×								
Urnatopteris, Kidston, 1884,												
tenella, Brongt. sp.,			×	×								
Crossotheca, Zeiller, 1883,												
Schatzlarensis, Stur sp.,			×									
Archæopteris, Dawson, 1882,												
Tschermaki, Stur,						×		×				
Reussii, Ett. sp.,			×									

Unatheca, Kidston, 1881,											
oblonga, Kidston,[4]	×										
Cyclotheca, Kidston, 1888,											
biseriata, Kidston,				×							
Calymmatotheca, Stur, 1877,											
affinis, L. and H. sp.,							×		×		×
bifida, L. and H. sp.,							×		×		×
asteroides, Lesqx. sp.,			×								
Sphyropteris, Stur, 1883,											
obliqua, Marrat sp.,			×								
Boehmischi, Stur,				×							
Hymenotheca, Potomie, 1890,											
Dathei, Potomie,			×								
Zeilleria, Kidston, 1884,											
Avoldensis, Stur sp.,			×								
delicatula, Sternb. sp.,			×								
Sorocladus, Lesqx., 1880,											
antecedens, Kidston,							×				×
Alcicornopteris, Kidston, 1887,											
convoluta, Kidston,							×		×		×
PECOPTERIDEÆ.											
Pecopteris, Brongt., 1822,											
arborescens, Schl. sp.,	×										
,, var. *cyathea*, Brongt. sp.	×										
oreopteridia, Schl. sp.,	×										

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[4] Mons. Zeiller has suggested that this genus should be united with *Hymenotheca*, Potomie, *Jahrb. d. königl. preuss. geologischen Landesanstalt für* 1889, p. 21, 1890. But in *Hymenotheca* the sporangia appear to be *annulate*, whereas in *Unatheca* I cannot discover any traces of an annulus.

Name.	General Distribution.							Lower Carboniferous.				Remarks.
	Upper Carboniferous.					Lower Carbonif.		Scotland.		England.		
	Coal-Measures.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand.	Carb. Lime.	Calcif. Sand.	Yoredale.	Mountain.	
Pecopteris—continued.												
Cistii, Brongt.,	×											
Bucklandii, Brongt.,	×											
pteroides, Brongt.,	×											
Miltoni, Artis sp.,[1]	×	×	×	×								[1] With *Pec. Miltoni*, Artis sp., I have united *Pec. abbreviata*, Brongt. Some authors keep these two plants separate, but I have failed to discover any character by which they can be distinguished. Some of Brongniart's types came from the Somerset Coal Field. I have only seen this species once in the Lower Coal-Measures. [2] Several species of *Pecopteris* are covered with short velvety hairs. Brongniart's type came from Camerton, Somerset. As the veins were not preserved on his specimen, it does not afford any clue for future identification, as the only specific character he gives is common to several species, and the form of the pinnules is not sufficiently distinctive. This is one of those species which it would perhaps be better to
crenulata, Brongt.,	×											
pinnatifida, Gutbier sp.,	×											
Lamuriana, Heer,	×											
Volkmanni, Sauveur,			×									
polymorpha, Brongt.,	×											
villosa, Brongt.,[2]	?											
Candolliana, Brongt.,	×											
unita, Brongt.,	×											
,, *formaemarginata*, Göpp. sp.,	×											

Dactylotheca, Zeiller, 1883, . .											
dentata, Brongt. sp.,[3] . .	×		×								
plumosa, Artis sp., . . .			×	×							
caudata, L. and H. sp., . .				×							
Mariopteris, Zeiller, 1879, . . .											
muricata, Schl. sp., . . .	×		×	×	×						
,, ***forma nervosa***, Brongt. sp.,			×	×	×						
Dicksoniites, Sterzel, 1883, . . .											
Pluckenetii, Schl. sp., . .	×										
ALETHOPTERIDEÆ.											
Alethopteris, Sternberg, 1820, . .											
lonchitica, Schl. sp.,[4] . .	×		×	×	×						
decurrens, Artis sp., . . .	×		×	×							
aquilina, Schl. sp., . . .	×		×								
Davreuxi, Brongt. sp., . .	×		×								
Serlii, Brongt. sp.,[5] . . .	×	×	×								
Grandini, Brongt. sp., . .	×										
valida, Boulay, ...			×								
Desmopteris, Stur, 1883, . . .											
longifolia, Presl. sp., . .	×										
Lonchopteris, Brongt., 1828, . .											
rugosa, Brongt., . . .			×								
Bricii, Brongt., . . .			×								
ODONTOPTERIDEÆ.											
Odontopteris, Brongt., 1822, . .											
Lindleyana, Sternb., . . .	×	×									
Britannica, Gutbier, . . .			×								

[3] I am now satisfied that *Dactylotheca dentata*, Brongt. sp., and *Dactylotheca plumosa*, Artis sp., are separate species. *Sphenopteris crenata*, L. and H., is synonymous with Artis's plant, of which I have now fruiting specimens from the Middle Coal-Measures of Yorkshire, which were collected by Mr Hemingway. These I hope to describe soon.

[4] *Alethopteris lonchitica*, Schl. sp., and *Aleth. decurrens*, Artis sp., are extremely rare in the Upper Coal-Measures, but are excessively abundant in the Middle and Lower Coal-Measures.

[5] *Aleth. Serlii*, Brongt. sp., is extremely abundant in the Upper Coal-Measures, but very rare in the Middle Coal-Measures.

NAME.	GENERAL DISTRIBUTION.							LOWER CARBONIFEROUS.				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.		SCOTLAND.		ENGLAND.		
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand.	Carb. Lime.	Calcif. Sand.	Yoredale.	Mountain.	
Odontopteris—continued.												
Reichiana, Gutbier,			×									
Coemansii, Andræ,[1]			×									[1] This plant I previously recorded as *Sphenopteris spinulosa*, Stur sp. (?), *Trans. Roy. Soc. Edin.*, vol. xxxv., p. 73, pl., fig. 2. Mons. Zeiller has pointed out its true designation, "Annuaire geologique universel," vol. viii., p. 873.
NEUROPTERIDEÆ.												
Neuropteris, Brongt., 1822,												
heterophylla, Brongt.,[2]		×	×	×	×							[2] See Remarks, *ante* p. 229.
tenuifolia, Schl. sp.,		×	×									
rarinervis, Bunbury,	×	×	×									
rectinervis, Kidston,				×								
ovata, Hoffm.,	×											
Grangeri, Brongt.,			×									
obliqua, Brongt. sp.,			×									
Elrodi, Lesqx.,			×									
microphylla, Brongt.,			×									
gigantea, Sternb.,[3]		×	×	×	×							[3] See Remarks, *ante* p. 229.
flexuosa, Brongt.,	×	×										
,, *forma rotundifolia*, Bgt. sp.,	×											
plicata, Sternb.,			×									
Osmundæ, Artis sp.,			×									
Scheuchzeri, Hoffm.,	×	×	×									

acuminata, Schl. sp.,			×	×							
crenulata, Brongt.,				×							
Blissii, Lesqx.,				×							
dentata, Lesqx.,			×								
fimbriata, Lesqx.,	×										
Schlehani, Stur,			×								
Germari, Göpp. sp.,			×								
(?) *antecedens*, Stur,						×		×			
Cardiopteris, Schimper, 1869,											
nana, Eichwald,						×		×			
sp.,							×		×		
sp.,							×		×		×
Dictyopteris, Gutbier, 1835,											
obliqua, Bunbury,[4]			×								
Münsteri, Eichwald sp.,	×		×								
Filicaceæ incertæ sedis.											
Rhacophyllum, Schimper, 1869,											
crispum, Gutbier sp.,	×										
lineare, Gutbier sp.,			×								
filiciforme, Gutbier sp.,	×										
anomalum, Brongt. sp.,			×								
Goldenbergii, Weiss,	×										
spinulosum, Lesqx.,	×										
Spiropteris, Schimper, 1869,											
sp.,	×		×								
FERN STEMS.											
Megaphyton, Artis, 1825,											
frondosum, Artis,	×		×	×							
approximatum, L. and H.,				×							
elongatum, Kidston,	×										

[4] Mons. Zeiller identifies the plant I have named *Dictyopteris obliqua*, Bunbury, as *Dictyopteris sub-Brongniarti*, Grand' Eury. With this identification I fully agree, but this species I have placed as a synonym to *Dictyopteris obliqua*. In the meantime, the question had better be left open.

NAME.	GENERAL DISTR											REMARKS.
	UPPER CARBONIFEROUS.											
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lin	C	Carb. Li	Cal	Yor	Mon	
Caulopteris, L. and H., 1832,												
primæva, L. and H.,	×											
(?) *macrodiscus*, Brongt. sp.,[1]	×											[1] All the specimens identified as *Caulopteris macrodiscus*, Brongt. sp., were decorticated, and though they agree entirely with Brongniart's figure, still they may be only decorticated specimens of one of the other species of *Caulopteris*.
cyclostigma, Lesqx.,	×											
anglica, Kidston,	×											
minuta, Kidston,							×		×		×	
EQUISETACEÆ.												
Equisetum, Linn.,												
Hemingwayi, Kidston,			×									
CALAMARIEÆ.												
Calamites (Suckow), Schl., 1820,												
Group I. *Calamitina*, Weiss, 1876.												
varians, Sternb.,			×	×	×							
,, var. *insignis*, Weiss,			×	×								
Schutzei, Stur,			×	×								
approximata, Brongt.,		×	×	×								
verticillata, L. and H.,			×	×								
Göpperti, Ett. sp.,		×	×	×								
undulata, Sternb. sp.,	×		×	×								
Group II. *Eucalamites*, Weiss, 1884.												

cruciatus, Sternb. sp., . .	×		×	×								
Britannicus, Weiss, . . .			×									
Group III. ***Stylocalamites***, Weiss, 1884.												
Suckowii, Brongt., . . .	×		×	×	×							
Cistii, Brongt., ...	×	×	×	×								
Schatzlarensis, Stur, . . .			×									
Roemeri, Göpp., . . .							×		×			
Asterocalamites, Schimper, 1862, .												
scrobiculatus, Schl. sp., . .						×	×	×	×		×	
Calamocladus, Schimper, 1869, . .												
equisetiformis, Schl. sp., . .	×	×	×	×								
longifolius, Sternb. sp., . .			×	×								
grandis, Sternb. sp., . . .			×	×								
charæformis, Sternb. sp., . .		×	×									
lycopodioides, Zeiller sp., . .			×	×								
Calamostachys, Schimper, 1869, . .												
typica, Schimper, . . .			×	×								
(?) *longifolia*, Weiss, . . .			×	×								
Paracalamostachys, Weiss, 1884, .												
Williamsonia, Weiss, . .			×									
Palæostachya, Weiss, 1884, . .												
pedunculata, Will., . . .			×	×								
gracillima, Weiss, . . .			×	×								
elongata, Presl. sp., . . .			×									
Volkmannia, Sternb., 1820, . .												
Morrisii, Hooker, . . .						×		×				
Macrostachya, Schimper, 1869, . .												
infundibuliformis, Brongt. sp., .	×											

Name.	General Dist											Remarks.
	Upper Carboniferous.											
	Coal-Measures.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lim	Calcif. S	Carb. Lin.	Calcif	Yoredale.	Mountain.	
Sphenopteris—continued.												
Jacquoti, Zeiller sp.,			×									
tenuifolia (Brongt.) Gutbier,	×											
effusa, Kidston,				?								
Woodwardii, Kidston,	×											
Linkii, Göpp. sp.,						×		×				
Hibberti, L. and H.,						×	×	×	×			
excelsa, L. and H.,							×		×			
Ettingshauseni, Feistm.,						×	×	×	×			
Haueri, Stur,						×		×				
crassa, L. and H.,						×	×	×	×			
pachyrrachis, Göpp,							×		×		×	
,, var. *stenophylla*, Göpp,							×		×		×	
Zobelli, Göpp.,			×	×								
Macconochii, Kidston sp.,							×		×			
spinosa, Göpp.,			×	×								
spiniformis, Kidston,[1]			×									
Sternbergii, Ett. sp.,			×	×								
furcata, Brongt.,			×	×								
flexuosa, Gutbier,			×									
Grandini, Göpp. sp.,	×											
geniculata, Germ. and Kaulf.,	×											
subgeniculata, Stur sp.,							×		×		×	
elegans, Brongt.,						×	×	×	×			
dissecta, Brongt.,			×	×								

[1] See *Trans. Yorkshire Nat. Union*, part xviii., 1893, p. 103.

ophiurus, Brongt., ...			×	×							
dichotomum, Zeiller (? not Sternb.)[2]	×	×									
lycopodioides, Sternb., . .			×	×							
Landsburgii, Kidston, . .			×	×							
lanceolatum, Lesqx., . . .	×										
aculeatum, Sternb., ...	×		×	×	×						
,, *forma modulatum*, Lesqx.,				×							
Veltheimianum, Sternb., . .						×	×	×	×		×
Haidingeri, Ett., ...		×	×								
obovatum, Sternb., ...			×	×	×						
longifolium, Sternb., . .			×								
Rhodeanum, Sternb., . . .						×	×	×	×		
Peachii, Kidston, ...				×							
serpentigerum, König., . .				×							
rimosum, Sternb., ...			×								
fusiforme, Corda, ...				×							
Jaraczewskii, Zeiller, . . .				×							
(?) *rhombicum*, Sternb. sp., .	×										
Wortheni, Lesqx., ...	×	×	×								
Volkmannianum, Sternb., . .							×		×		×
Lepidostrobus, Brongt., 1828, . .											
variabilis, L. and H., . .	×		×	×		×	×	×	×		
comosus, L. and H., . . .							×		×		
spinosus, Kidston, . . .	×			×							
squarrosus, Kidston, . . .				×							
anthemis, König. sp., . .			×								
oblongifolius, Lesqx., . . .	?										
fimbriatus, Kidston, . . .							×		×		×
lanceolatus, L. and H. sp., .	×		×	×			×		×		×
Geinitzii, Schimper, . . .			×	×							
Lepidophyllum, Brongt., 1828, . .											
majus, Brongt., ...	×		×	×							

[2] *Lepidodrendron dichotomum*, Zeiller (? not Sternb.), is very rare in Britain. The plants usually referred to under this name in Britain are generally *Lepid. ophiurus*, Brongt., or *Lepid. lycopodioides*, Sternb.

NAME.	GENERAL DISTRI											REMARKS.
	UPPER CARBONIFEROUS.											
	COAL-MEASURES.									AND.		
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand	Carb. Lime.	Calcif. San	Yoredale.	Mountain.	
Schizostachys, Grand' Eury, 1877,												
sphenopteroides, Kidston,	×											
Corynepteris, Baily, 1860,												
erosa, Gutbier sp.,	×											
coralloides, Gutbier sp.,			×									
Renaultia, Zeiller, 1883,												
microcarpa, Lesqx. sp.,				×								[1] *Sphenopteris gracilis*, Brongt., "Hist. d. végét. foss.," p. 197, pl. liv., fig. 3. If the fern described and figured by Zeiller in his "Flore foss. d. bassin houil. de Valenciennes," p. 94, pl. iv., figs. 2 and 3, as *Renaultia gracilis*, Brongt. sp., is really that plant, then *R. Footneri*, Marrat sp., must be reduced to a synonym of Brongniart's species. *Renaultia Footneri* occurs on the same horizon as *Renaultia* (*Sphen.*) *gracilis*, Brongt., but I have not yet clearly satisfied myself that the plants are identical,—possibly they are, however. Unless this is the case, I have not yet seen *Sphen. gracilis*, Brongt., in Britain.
Footneri, Marrat sp.,			×	×								
gracilis, Brongt. sp.,[1]				×								
Schatzlarensis, Stur sp.,			×	×								
Urnatopteris, Kidston, 1884,												
tenella, Brongt. sp.,			×	×								
Crossotheca, Zeiller, 1883,												
Schatzlarensis, Stur sp.,			×									
Archæopteris, Dawson, 1882,												
Tschermaki, Stur,						×		×				
Reussii, Ett. sp.,			×									

Section III. *Rhytidolepis.*											
tessellata (Schl.), Brongt.,	×	×	×	×	×						
elegans (Sternb.), Brongt.,			×	×							
nodosa (Bowman MS.), L. and H.,[3]			×								
mamillaris, Brongt.,		×	×	×							
,, var. *vulgaris*, Artis sp.,			×								
***polyploca*, Boulay,**		×	×								
***contracta*, Brongt.,[4]**			×								
scutellata, Brongt.,		×	×	×	×						
Boblayi, Brongt.,			×								
lenticularis, Sauveur,				×							
rugosa, Brongt.,		×	×	×							
elongata, Brongt.,		×	×								
Deutschiana, Brongt.,			×								
coriacea, Kidston,				?							
Walchii, Sauveur,				×							
Saulii, Brongt.,			×								
Schlotheimii, Brongt.,		×									
Arzinensis, Corda,			×	×							
orbicularis, Brongt.,				×							
tenuis, Achep.,			×	×							
principis, Weiss,			×								
lævigata, Brongt.,	×		×								
reniformis, Brongt.,	×		×								
,, var. ***Radstockensis*, Kidston,**	×										
***cordigera*, Zeiller,**			×								
***ovata*, Sauveur,**			×								

[3] I have long had difficulty in understanding Bowman's *Favularia nodosa* in Lindley and Hutton's "Fossil Flora," vol. iii., pl. cxcii. The British Museum now possess a specimen from Clay Cross, Derbyshire, which agrees very fairly with Bowman's species, which in turn appears to hold close relationship to *Sig. tessellata*, Brongt.

[4] I only know this species from Brongniart's description and figure.

NAME.	GENERAL DIST											REMARKS.
	UPPER CARBONIFEROUS.											
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand	Carb. Lin	Calcif. Sa	Yoredale.	Mountain.	
Pecopteris—continued.												
Cistii, Brongt.,	×											
Bucklandii, Brongt.,	×											
pteroides, Brongt.,	×											
Miltoni, Artis sp.,[1]	×	×	×	×								[1] With *Pec. Miltoni*, Artis sp., I have united *Pec. abbreviata*, Brongt. Some authors keep these two plants separate, but I have failed to discover any character by which they can be distinguished. Some of Brongniart's types came from the Somerset Coal Field. I have only seen this species once in the Lower Coal-Measures. [2] Several species of *Pecopteris* are covered with short velvety hairs. Brongniart's type came from Camerton, Somerset. As the veins were not preserved on his specimen, it does not afford any clue for future identification, as the only specific character he gives is common to several species, and the form of the pinnules is not sufficiently distinctive. This is one of those species which it would perhaps be better to drop from our lists.
crenulata, Brongt.,	×											
pinnatifida, Gutbier sp.,	×											
Lamuriana, Heer,	×											
Volkmanni, Sauveur,			×									
polymorpha, Brongt.,	×											
villosa, Brongt.,[2]	?											
Candolliana, Brongt.,	×											
unita, Brongt.,	×											
,, *formaemarginata*, Göpp. sp.,	×											

Cordaites, Unger, 1850,											
Group I. *Cordaites.*											
borassifolius, Sternb. sp.,	×		×	×							
principalis, Germar sp.,			×	×	×						
angulosostriatus, Grand' Eury,	×	×									
sp.,							×		×		
Group II. *Dorycordaites*, Grand' Eury, 1877.											
palmæformis, Göpp. sp.,			×								
Group III. *Poacordaites*, Grand' Eury, 1877.											
microstachys, Gold. sp.,	×										
Cordaianthus, Grand' Eury, 1877,											
Pitcairniæ, L. and H. sp.,			×	×							
subacutus, Grand' Eury,			×								
anomalus, Morris sp.,			?								
Volkmanni, Ett. sp.,			×								
Cardiocarpus, Brongt., 1828,											
fluitans, Dawson,	×		×								
Meachemii, Kidston,			×								
marginatus, Artis sp.,			×								
Gutbieri, Geinitz,	×		×								
Cordai, Geinitz,			×								
nervosus, Kidston,[4]							×				×
orbicularis, Ett.,				×							
bicaudatus, Kidston,[5]							×		×		

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[4] For description, see following communication, p. 266, pl. v., figs. 3, 4, 5.

[5] For description, see following communication, p. 367, pl. vi., figs. 3, 4.

NAME.	GENERAL DISTRIBUTION.							LOWER CARBONIFEROUS.				REMARKS.
	UPPER CARBONIFEROUS.					LOWER CARBONIF.		SCOTLAND		ENGLAND.		
	COAL-MEASURES.											
	Upper.	Transition.	Middle.	Lower.	Millstone.	Carb. Lime.	Calcif. Sand.	Carb. Lime.	Calcif. Sand.	Yoredale.	Mountain.	
Carpolithus, Schloth., 1820,												[1] These little seeds I have frequently recorded as *Carpolithus bivalvis*, Berger ("De fruct. et semin.," p. 26, pl. ii., figs. 30, 31, 1848), thinking that *Carpolithus perpusillus*, Lesqx. ("Coal Flora," vol. iii., p. 825, pl. cxi., figs. 22-24, 1884), was the same. Some individuals agree with the figures of Berger, and others better with the Lesquereux's figures. I doubt very much their specific difference. [2] K. Feistmantel, Archiv. der naturwiss. Landesdurchforschung v. Böhmen, IV. Band, No. 6, Geolog. Abth. Prag., 1881, p. 99, pl. vii., figs. 4, 5. [3] See for figure *Trans. Nat. Hist. Soc. Glasgow*, 1869, vol. i., pl. iv., figs. 9, 10.
perpusillus, Lesqx.,[1]			×	×								
disciformis, Sternb.,			×									
inflatus, Lesqx.,			×									
Wildii, Kidston,			×									
(?) *insignis*, Feistm.,[2]	×											
ovoideus, Göpp.,			×	×								
sulcata, L. and H.,							×		×			
Trigonocarpus, Brongt., 1828,												
Parkinsoni, Brongt.,		×	×	×								
,, var. *amygdalæformis*, G. & B. sp.			×									
,, var. *Bockschianus*, G. & B. sp.,			×									
oblongus, L. and H.,			×									
Noeggerathi, Sternb. sp.,	×	×	×									
ovatus, L. and H.,			×									
Dawesii, L. and H.,			×									
Gloagianum, J. Young,[3]						×		×				
Polypterocarpus, Grand' Eury, 1877,												
sp.,			×									
sp.,			×									
Rhabdocarpus, Göpp. and Berger												

Schutzia, Geinitz, 1863,												
Benniceana, Kidston,							×		×			
Cordaioxylon, Grand' Eury, 1877,												
Brandlingii, Witham sp.,			×	×								
Cedroxylon, Kraus., 1870,												
Withami, L. and H. sp.,				?								
Araucarioxylon, Kraus., 1870,[4]												[4] See Remarks, *ante* p. 236.
Withami, L. and H. sp.,							×		×		×	
medullaris, L. and H. sp.,							×		×			
primævum, Witham sp.,							×		×		×	
Artisia, Sternb., 1838,												
transversa, Artis sp.,			×		×							
approximata, Brongt. sp.,	×		×	×	×							
Psygmophyllum, Schimper, 1870,												
flabellatum, L. and H. sp.,				×								
CONIFERÆ.												
Walchia, Sternb., 1825,												
imbricata, Schimper,	×											
Gnetopsis, Renault and Zeiller, 1885,												
sp.,			×									
ROOTLETS.												
Pinnularia, L. and H., 1834,												
prostrata, Artis sp.,			×	×								
capillacea, L. and H.,	×		×	×								

XVI. *On some New Species of Fossil Plants from the Lower Carboniferous Rocks of Scotland.* By ROBERT KIDSTON, F.R.S.E., F.G.S. [Plates IV.–VI.]

(Read 20th December 1893.)

This paper may be regarded as an appendix to the Address I had the pleasure of delivering last month.

At the end of my Address I gave a list of all the species of Carboniferous plants I had yet identified in Britain, showing the horizons from which they had been derived. In that list I included the following six new species, which I now describe.

Plumatopteris elegans, n. gen. and n. sp.
Sphenopteris Dunsii, n. sp.
Rhacopteris subcuneata, n. sp.
Sigillaria Youngiana, n. sp.
Cardiocarpus nervosa, n. sp.
Cardiocarpus caudatus, n. sp.

PLUMATOPTERIS, Kidston, n. gen.

Description.—Frond bipinnate (or tripinnate ?), pinnæ alternate, oblong or linear oblong, obtuse, entire or sinuous or more or less lobed, nerves numerous, simple or bifurcated, springing from the midrib at an acute angle and running to the margin with only a slight curvature in their course.

Remarks.—The fern which forms the type of this genus finds its nearest allies in *Archæopteris Tschermaki*, Stur,[1] and *Archæopteris Dawsoni*, Stur,[2] and perhaps these two species might find a place in *Plumatopteris.*

In the absence of any knowledge of the fructification of these three fossils, and the entirely different mode of the pinnule cutting, none of them have any claim to be placed in Dawson's *Archæopteris*, of which the outstanding character is the fructification.[3]

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[1] Culm Flora, vol. i., p. 57, pl. xii., fig. 1.

[2] *Ibid.*, p. 60, pl. xii., figs. 2, 3, 4.

[3] Dawson, Plants of the Erian (Devonian) and Upper Silurian Formations of Canada, part ii., p. 98, 1882. See also Kidston, Trans. Geol. Soc. of Glasgow, vol. ix., p. 30, 1891.

PLUMATOPTERIS ELEGANS, Kidston, n. sp.

[Plate V., Figs. 1 and 1*a*.]

Description.—Frond bipinnate (or tripinnate ?), pinnæ oblong, blunt, alternate, sessile, decurrent, entire, sinuous or slightly lobed in their basal portion. Midrib distinct, and giving rise to numerous thin simple or dichotomous veinlets, which spring from the midrib at an acute angle, and run with only a slight curvature to the margin. The bifurcation of the veinlets takes place close to the midrib, so that the veinlets generally appear to be simple.

Remarks.—The pinnæ are almost entire except at their lower part where they join the rachis; here, on the upper side, and occasionally also on the lower side, a small oblong pinnule is separated off. Any appearance of pinnules on the upper part of the pinnæ seem to result more from the effect of a splitting of the tissue than a distinct pinnule formation. The pinnæ are slightly decurrent, but the rachis is not winged.

Horizon.—Carboniferous Limestone Series; Lower Limestone Series of the Calderwood group.

Locality.—Limekilns, East Kilbride, Lanarkshire.

The specimen figured was, I believe, collected by the late Mr A. Patton.

SPHENOPTERIS DUNSII, Kidston, n. sp.

[Plate IV., Figs. 1-4.]

Description.—Frond broadly lanceolate, tripinnate, primary pinnæ deltoid lanceolate, opposite on lower, but alternate on upper part of frond; secondary pinnæ alternate, lanceolate, bearing at the base of the lower pinnæ a few small lanceolate tertiary pinnæ; the upper portion of the lower secondary pinnæ, and the whole of the uppermost secondary pinnæ merely bear lobed or entire pinnules. Pinnules very small, about 1 mm. long, oval or lobed; nervation sphenopteroid. Main rachis moderately thick, and finely striated longitudinally.

Remarks.—The general aspect of *Sphenopteris Dunsii* reminds one much of certain *Cheilanthes* in its small pinnules and graceful form.

At Plate IV., Fig. 2, is shown the most perfect specimen I have yet met with as far as exhibiting the details of the pinnule cutting. Plate IV., Fig. 1, gives a better idea of the growth of the fern, and is probably from near the centre of the frond, while Fig. 2 evidently represents a portion from near the base.

The very small oval pinnules are closely placed together and generally overlap each other. They seem to have been of delicate texture, and little able to resist decomposition. When decayed, their remains unite to form a dense black stain on the matrix, which only shows the general outline of the pinnæ. This is the condition in which the plant mostly occurs, and is shown at Fig. 1. If we were to judge from this figure, it would probably be concluded that the pinnules were much larger than they are, and bore several lobes. Fig. 2, however, shows that the pinnules are oval and very small, about 1 mm. long, simple on the upper portions of the ultimate pinnæ as seen at Fig. 3, which is magnified eight times. At the base of the ultimate pinnæ they are lobed or dentate, as seen at Fig. 4, which is also enlarged eight times. The nervation is not distinctly shown, but what has been preserved is represented in the enlargements.

Sphenopteris Dunsii is not common, and even the few specimens I have met with are seldom well preserved. Those figured here are the two best I have yet seen.

It gives me pleasure to name this fossil after Professor Duns, of the New College, Edinburgh.

The specimen figured on Plate IV., Fig. 2, I received some years ago from the late Mr D. Grieve.

Horizon.—Cement Stone Group of the Calciferous Sandstone Series.

Localities.—Colinton (the late Mr D. Grieve), West Hermand (the late Mr C. W. Peach), and Burdiehouse, near Edinburgh, Midlothian.

RHACOPTERIS SUBCUNEATA, Kidston, n. sp.

[Plate V., Fig. 2; Plate VI., Fig. 1.]

Description.—Frond pinnate, rachis thick, pinnules alternate, lax, and divided usually into about eight linear, subcuneate segments. Veins obscure.

Remarks.—Several specimens of this species have been collected, of which two are shown on Plates V. and VI.

Fig. 1, Plate VI., gives the lower part of a frond, the rachis is stout, being over 3 mm. thick, and gives off lax pinnules, which are usually divided into six or seven linear subcuneate or spathulate segments—each pair of segments seem to form the two arms of a dichotomy.

Plate V., Fig. 2, shows the upper portion of a frond.

The lax mode of growth of this species forms one of its distinguishing characters.

Rhacopteris subcuneata is distinguished from *Rhacopteris flabellata*, Tate sp., by its clavate pinnule segments, and also by its laxer growth, and from *Rhacopteris Geikiei*, Kidston, where the pinnule segments are linear, and spring from the sides of a common central axis; while in *Rhacopteris subcuneata* the pinnule lobes spring in a flabellate manner from a very short foot-stalk. The nervation is not shown on any of the specimens, all of which were collected by Mr J. Rhodes. The types are preserved in the collection of the Geological Survey of Great Britain, Museum, Jermyn Street, London.

Horizon.—Calciferous Sandstone Series; Lower Limestone Series; Lewis Burn Coal Group.

Locality.—East bank of Lewis Burn, Barney's Cut, a little over a quarter mile south-west of Lewis Burn Bridge, North Tynedale, Northumberland.

SIGILLARIA YOUNGIANA, Kidston, n. sp.

[Plate VI., Figs. 2 and 2*a*.]

Description.—Stem ribbed, ribs alternately contracted and expanded; leaf-scars placed rather above the centre of the expansions, slightly broader than long, emarginate at top, lateral angles much developed, lower margin semicircular and forming a sinus at each side where it joins the lateral angles; cicatricules three, the lateral lunate, the central punctiform. Above the leaf-scar the ribs are ornamented with fine lines somewhat irregularly placed, but soon assuming a general direction parallel to the ribs. From the sinus at the top of the leaf-scar two lines extend upwards and outwards for a short distance.

I have named this *Sigillaria* after its discoverer, Dr John Young, of the Hunterian Museum, Glasgow, who found it in 1864 in a bed of shale passed through in sinking a pit to reach the upper Possil blackband ironstone and associated coal at Robroystone, near Glasgow.

Its nearest ally appears to be *Sigillaria contracta*, Brongt.,[1] but it is easily distinguished from this species by the form and position of the leaf-scars, as well as by the ornamentation of the ribs.

In *Sigillaria contracta*, Brongt., the leaf-scars are placed on the contracted portions of the ribs, while in *Sigillaria Youngiana* they are on the expanded areas. The form of the leaf-scar in the former is pyriform, with feebly developed lateral angles; in *Sig. Youngiana* it is emarginate, broader than long, and the lateral angles are developed to an unusual extent. The ornamentation of the ribs is also different. The two species are very distinct, and the only point they have in common is the alternately contracted and expanded ribs.

Sigillaria Youngiana, of which a single specimen has been found, is the only example of a ribbed *Sigillaria* I have yet seen from the Lower Carboniferous Rocks of Britain, and this circumstance adds considerable interest to the fossil.

The specimen has been placed in the collection of the Hunterian Museum of the University, Glasgow, by Dr John Young, and my thanks are due to him for his kind permission to figure and describe it.

Horizon.—Carboniferous Limestone Series; Possil Ironstone Group.

Locality.—Robroystone, about four miles north-east of Glasgow, Lanarkshire.

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[1] Hist. d. végét. foss., p. 459, pl. cxlvii., fig. 2.

SEEDS.

The genus *Cardiocarpus*, Brongt.,[1] has been divided into several genera, which, however, all appear to hold a close relationship to each other.

While *Cardiocarpus*, Brongt., is still retained for certain seeds, *Samaropsis*, Göppert, and *Cordaicarpus*, Geinitz, have been founded for seeds which, I believe, would have been included by Brongniart in his genus.

Brongniart's original description of his genus is:—

Cardiocarpus, Brongniart, 1828.

Cardiocarpon, Prodrome, p. 87.

"Fruit compressed, lenticular, cordate or reniform, acuminate."

He included in it five species, *C. majus*, *C. Pomieri*, *C. cordiforme*, *C. ovatum*, and *C. acutum*.

None of these species were described when Brongniart gave them as members of his genus, and only one of these names appears to have since had a description added to it, viz., *Cardiocarpus acutus*, which was described by Lindley and Hutton in their "Fossil Flora," vol. i., pl. lxxvi., 1883. Lindley and Hutton are, therefore, the authors of *Cardiocarpus acutus*, and not Brongniart, though they give Brongniart's name as the authority for their species, and refer in support of this to his "Prodrome;" still, there is no evidence to show that the fossil so named by Lindley and Hutton was similar to that meant by Brongniart, for Brongniart never gave any description of his plant. We, in fact, must presume it was not the same if the genus *Samaropsis*, Göppert, is to be retained, for the distinctly winged seed of *Cardiocarpus acutus*[2] would, according to Göppert's description of his genus, place it in *Samaropsis*.

Göppert's definition of *Samaropsis* is very short, and not very clear. I append it here.

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[1] Prodrome, p. 87, 1828.

[2] This I believe to be the seed of *Cordaites principalis*, Germar sp.

Samaropsis, Göppert, 1864.

Foss. Flora d. perm. Form., p. 177.

"Seeds with membranaceous wings, compressed, monospermous."[1]

This genus is more fully defined by Zeiller in his "Flore foss. d. bassin houil. d. Valenciennes," p. 643.

Seeds generally very small, flat, lenticular in section, oval in shape, pointed or slightly emarginate at the summit, and sometimes cordate at the base, completely bordered by a membranous wing, which is more or less developed.

An examination of Göppert's figures shows that this description of *Samaropsis* by Zeiller coincides completely with the plants included in it by its author.

The third genus in which some of these little seeds have been placed is *Cordaicarpus*, Geinitz.

Cordaicarpus, Geinitz, 1862.

Cordaicarpon, Dyas, p. 150.

"Lenticular or compressed globular, ovate to roundly cordate, seed surrounded by a close envelope of leathery consistency, to which a short stem is attached. Probably the fruit of *Cordaites*. Type: *Carpolithes Cordai*, Geinitz."

Zeiller includes *Cardiocarpus*, Brongt. (in part), in *Cordaicarpus*, Geinitz, and defines the latter genus thus:—

Cordaicarpus, Geinitz.

Zeiller, Flore foss. d. bassin houil. d. Valen., p. 645, 1888.

Seeds flattened in transverse section, elliptical or lenticular, in form oval or orbicular, acuminate or obtusely pointed at the summit, often a little emarginate at the base, surrounded by a keel more or less prominent, surface smooth.

Göppert and Fiedler in 1857[2] founded the genus *Cyclocarpus* for circular seeds having the same general characters as those which had been placed by Geinitz in his *Cordaicarpus,* only in the former genus the seeds included in it were restricted to those of circular form, whereas in *Cordaicarpus* they might either be circular or oval-cordate. *Cyclocarpus* is now generally united with *Cordaicarpus.*

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[1] "Fructus samaroideus membranaceus, compressus, margine alatus monospermus."

[2] Die foss. Früchte d. Steinkohlen Form., by H. Fiedler—Nov. Act. Acad. nat. curios, vol. xxxvi., p. 291.

From the remarks just made, it will be seen that there is very little difference between the generic characters of *Cardiocarpus, Samaropsis,* and *Cordaicarpus,* except in the degree of development of the keel or wing.

As these genera are *generally* employed, *Cardiocarpus* would appear to have a feebly developed wing, *Samaropsis* a strongly developed membranous wing, while in *Cordaicarpus* perhaps the seeds did not possess a wing, and the apparent wing in their fossil state arises from the flattening of the pericarp, which, extending past the nucule, appears in this condition as a narrow surrounding wing or keel.

It is true that Brongniart does not refer to the seeds being winged in the definition of his genus *Cardiocarpus,* but it is evidently for these more or less winged seeds that Brongniart created his genus. The tendency, however, seems to be to pass over Brongniart's *Cardiocarpus* in favour of the newer genus *Samaropsis,* Göppert.

If, on the other hand, those seeds with broad wings be placed in *Samaropsis,* and those with narrow wings in *Cardiocarpus,* the difficulty arises as to where the line of demarcation is to be drawn.

Zeiller gives *Cardiocarpus* an equal generic position with *Samaropsis* and *Cordaicarpus,* and he defines it as—

Cardiocarpus, Brongt.

Zeiller, Flore foss. d. bassin houil. d. Valen., p. 647.

Seeds flat, in section transversely lenticular, in form cordate or reniform, acuminate or bluntly pointed at the summit, cordate at the base, surrounded by a keel more or less prominent, and generally formed of a hard seed surrounded by a fleshy envelope.

In the condition in which the seeds are usually found, which Zeiller places in *Cardiocarpus,* they have a narrow keel or wing-like border, which it appears to me may result from pressure on a pericarp of softer consistency than the nucule, though it is possible that the seeds were provided with true narrow wings. Nevertheless, it is difficult to see how *Cardiocarpus*, as here defined, can be satisfactorily separated from *Cordaicarpus*.

To sum up the matter, it would appear that of the little seeds under discussion, some possessed a true surrounding membranous wing-like structure, while in others the narrow wing-like border or keel with which they are usually provided in the fossil state, probably results from the compression of a more or less soft envelope which surrounded the seed.

In these circumstances, would it not be better, either to suppress Brongniart's genus *Cardiocarpus* as insufficiently defined, and to use *Samaropsis*, Göpp., for the seeds possessing undoubted membranous wing-like structures, and *Cordaicarpus*, Geinitz, for those whose apparent narrow wing or keel is the probable result of pressure, or *tentatively*, to place all these seeds in Brongniart's *Cardiocarpus?* This last course is that adopted here.

CARDIOCARPUS NERVOSUS, Kidston, n. sp.

[Plate V., Figs. 3, 4, and 5.]

Description.—Form of complete seed, cordate, flat; nucule acuminate, lenticular in transverse section, broadly winged, membranous wing with several simple or divided vein-like thickenings passing from the margin of the nucule to the outer edge of the wing.

Remarks.—The best preserved of these little seeds is shown at Figure 3; its entire width is about 1 cm., the nucleus measuring about 5 mm., and the wings about 2·5 mm. each.

At the base of the seed the wing narrows, and a notch is thus formed which gives the seed a cordate outline.

None of the specimens show the apex sufficiently well preserved to determine whether the wing was continuous or cleft at the apex. The character which at once distinguished this species is the strong vein-like markings which extend from the margin of the nucleus to the periphery of the wing. These veins are usually simple, but occasionally forked.

The specimens which are in the Collection of the Geological Survey of Great Britain, Museum, Jermyn Street, London, were collected by Mr J. Rhodes.

Horizon.—Calciferous Sandstone Series; Lower Limestone Series; Cement Stone Group.

Localities.—Horncliffe Dean, near mill, river Tweed; south of Horncliffe village, Northumberland; River Coquet, ½ mile N.N.E. of Holystone, Northumberland.

CARDIOCARPUS BICAUDATUS, Kidston, n. sp.

[Plate VI., Figs. 3, 4.]

Description.—General form cordate-apiculate, with two tail-like downward expansions of the membranous wing; nucule oval, acute, lenticular in transverse section, wing broad, smooth, entirely surrounding the seed, apiculate at apex, and at the base extending into two long tail-like lobes.

Remarks.—The largest specimen, Pl. VI., Fig. 3, is 1·5 cm. broad and about 1·4 cm. long, measured from the sinus between the tail-like wings. The wings are about 5 mm. broad, and the two lobes are about 1 cm. long. The nucule is oval-acuminate, and surrounding it is a thickened vein-like band which extends to the apex of the two basal lobes. This is exhibited in both the figures of the species. These two vein-like structures extend upwards, round the nucule, and end in a short excurrent point as seen at Fig. 4. If we except the two caudate appendages, the fossil has very much the appearance of the seed of the elm.

Horizon.—Calciferous Sandstone Series; (Cement Stone Group.)

Locality.—Long Craig Bay, about 1½ mile west of Dunbar, Haddingtonshire.

EXPLANATION OF PLATES.

Plate IV.

Fig. 1. *Sphenopteris Dunsii*, Kidston.
Locality.—Burdiehouse, near Edinburgh.
Horizon.—Calciferous Sandstone Series (Reg. No. 649).
Fig. 2. *Sphenopteris Dunsii*, Kidston.
Locality.—Colinton, Midlothian.
Horizon.—Calciferous Sandstone Series (Reg. No. 650).
Figs. 3, 4. Pinnules from specimen shown at Fig. 2; × 8.

Plate V.

Fig. 1. *Plumatopteris elegans*, Kidston.
Locality.—East Kilbride, Lanarkshire.
Horizon.—Carboniferous Limestone Series (Reg. No. 791).
Fig. 1*a*. Portion of Fig. 1, slightly enlarged.
Fig. 2. *Rhacopteris subcuneata*, Kidston.
Locality.—Lewis Burn, North Tynedale, Northumberland.
Horizon.—Calciferous Sandstone Series.
Specimen in the Collection of the Geological Survey of England.
Figs. 3-5. *Cardiocarpus nervosus*, Kidston.
Locality.—Horncliffe Dean, river Tweed, Northumberland.
Horizon.—Calciferous Sandstone Series.
Specimens in the Collection of the Geological Survey of England.

Plate VI.

Fig. 1. *Rhacopteris subcuneata*, Kidston.
Locality.—Lewis Burn, North Tynedale, Northumberland.
Horizon.—Calciferous Sandstone Series.
Specimen in the Collection of the Geological Survey of England.
Fig. 2. *Sigillaria Youngiana*, Kidston.
Locality.—Robroystone, Lanarkshire.
Horizon.—Carboniferous Limestone Series.
Specimen in the Hunterian Museum, University of Glasgow.
Fig. 2*a*. Leaf-scar, enlarged.
Figs. 3, 4. *Cardiocarpus bicaudatus*, Kidston.
Locality.—Long Craig Bay, 1½ mile west of Dunbar, Haddingtonshire.
Horizon.—Calciferous Sandstone Series (Reg. Nos. 1940 and 1941).

My thanks are due to Sir Archibald Geikie for permission to describe the specimens belonging to the Geological Survey Collection.

The specimens distinguished by Registration numbers are in the author's collection.

XVII. *On* Cephalaspis magnifica, *a new Fossil Fish from the Caithness Flagstones.* By R. H. TRAQUAIR, Esq., M.D., LL.D., F.R.S. [Plate VII.]

(Read 20th December 1893.)

Fishes of the family Cephalaspidæ are, as is well known, especially characteristic of the uppermost Silurian and lowermost Devonian rocks. Only one solitary species (*Cephalaspis laticeps*, Traq.) has occurred in the Upper Devonian of Canada.

But though the family is well represented in the Lower Old Red Sandstone of the West of England by species of the genera *Cephalaspis*, *Auchenaspis*, and *Didymaspis*, and though *Cephalaspis* is the most characteristic genus of fossil fish in the corresponding rocks of the central area of Scotland, not a single remnant of a Cephalaspidian had ever been found in that great Orcadian area of Old Red Sandstone, which includes all the rocks of that formation north of the Grampian Mountains, and is supposed to have been deposited in the hypothetical Lake Orcadie.[1] Notwithstanding the richness of the fish-fauna of these rocks, Cephalaspidæ have hitherto been conspicuous by their absence. It was, therefore, with a feeling of agreeable surprise that, in the month of August of this year, I recognised in a fossil deposited in the office of the Caithness Flagstone Company at Thurso, and recently discovered by their workmen in the great pavement quarry at Spital, about ten miles inland, a veritable *Cephalaspis*, of unusual size for the genus, and belonging to an undescribed species. On learning my opinion of its importance, the officials of the company, with characteristic public spirit and generosity, at once presented this specimen to the Edinburgh Museum of Science and Art.

Accordingly, at the meeting of the British Association, which was held at Nottingham in the following September, I announced this discovery, and briefly described the specimen under the name of *Cephalaspis magnifica*, and an abstract of the paper read on that occasion has been already published in the *Annals of Scottish Natural History* for October last. In the present communication I propose to give a more detailed description of the fish, along with an accurate figure.

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[1] See Sir A. Geikie's paper On the Old Red Sandstone of Western Europe—Trans. Roy. Soc. Edin., vol. xxviii., 1878, p. 354.

The species of *Cephalaspis* which have been previously recognised are as follows:[1]—

C. Murchisoni, Egert. (*Hemicyclaspis*, Lank.). Ludlow Tilestone and Old Red Sandstone Passage Beds, Herefordshire.

C. Lightbodii, Lank. Ludlow Tilestones, Ludlow.

C. Lyelli, Agass. Lower Devonian (Old Red Sandstone), Forfarshire, Perthshire, Lanarkshire. With this species Mr Smith Woodward unites *C. Agassizii*, Lank., from the West of England.

C. Salweyi, Egert (*Zenaspis*, Lank.). Lower Devonian (Cornstones), Herefordshire.

C. Powriei, Lank. Lower Devonian (Old Red Sandstone), Forfarshire.

C. Pagei, Lank. Lower Devonian (Old Red Sandstone), Forfarshire. Mr Smith Woodward confirms Lankester's suspicion that *C. asper*, Lank., may only be the adult form of *C. Pagei*.

C. Dawsoni, Lank. Lower Devonian, Gaspé, Canada.

C. Campbelltownensis, Whiteaves. Lower Devonian, Campbelltown, Canada.

C. Jexi, Traquair. Lower Devonian, Campbelltown, Canada.

C. laticeps, Traquair. Upper Devonian, Scaumenac Bay, Canada.

Cephalaspis magnifica.

Cephalaspis magnifica, Traquair, Brit. Assoc. Rep., Nottingham, 1893; Ann. Scot. Nat. Hist., Oct. 1893, pp. 206-7.

The new species from Caithness (Pl. VII.) is large, exceeding in size any *Cephalaspis* hitherto described, even the comparatively gigantic *C. Salweyi*, Egert., and *C. Jexi*, Traq. Being crushed perfectly flat, the contour of the shield appears broader than it would have been had its natural vaulting been preserved. The left cornu is perfect, but the right one is injured,—had that not been the case, the shield would have measured no less than 12 inches across in the flattened condition. The limits of the posterior margin of the shield are not very definite, and behind it there are some rather obscure remains of the body scales.

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[1] For references to the previous literature of *Cephalaspis* up to 1891, see A. Smith Woodward's Cat. Foss. Fishes Brit. Mus., pt. ii., pp. 176-200. *C. Jexi*, Traq., is characterised in Geol. Mag. (3), vol. x., 1893, p. 147; also in Proc. Roy. Phys. Soc. Edin., vol. xi., 1893, p. 114.

The following measurements of the cephalic shield may be noted:—

Length of shield from back to front, ...	8½	inches.
Semi-diameter from mesial line across broadest part on left side, ...	6	,,
Semi-diameter to tip of left cornu, ...	5¾	,,
From tip of snout to opposite anterior margins of orbits, .	3½	,,
From tip of snout straight to tip of left cornu, . .	11	,,
Breadth across base of cornu, ...	1¾	,,
Length of cornu, ...	2¾	,,

The snout is bluntly pointed, the cornu comparatively short and broad-based, as seen by the above measurements, and is not provided with any denticulations along the inner margin.

The orbits are oval, 1 inch in diameter antero-posteriorly, ⅜ inch transversely, while the width of the interorbital space is 1$\frac{9}{16}$ inch. Owing to the extreme flattening of the shield, no traces are seen of the various fossæ and prominences ordinarily seen in connection with the orbital region in *Cephalaspis*, except in the case of the "post-orbital valley," the position of which seems fairly well indicated.

The contour of the reflected edge of the shield, which is, of course, ventral in position, is clearly seen through the dorsal portion, much of which has indeed been removed (and lost) with the counterpart of the fossil. This inferior rim is continuous all round, and not open or interrupted behind as in Lankester's figure of the lower surface of the shield in *C. Lyelli*.[1] It encloses a rounded-quadrangular area, whose angles are anterior, posterior, right, and left, and whose centre is rather in front of the eyes. Each diagonal of this area measures 6 inches.

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[1] Fishes of the Old Red Sandstone, Cephalaspidæ—Palæont. Soc. for 1869, p. 37, fig. 12.

The outer layer of the shield is unfortunately not present over much of the surface, though its ornamentation is here and there visible. This ornamentation consists of an excessively minute tuberculation, which is, however, coarser and more marked round the edges of the shield, and of the orbits (Pl. VII., Fig. 2), as well as along the inner margin of the cornu. The pseudo-tessellation of the middle layer is well seen, the tesseræ (Fig. 4) being mostly $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter, which is very small in proportion to the size of the shield. The specimen exhibits no trace of the radiating vascular canals usually seen in connection with the inner layer of the shield in *Cephalaspis.* The body remains are too obscure for description, but clear evidence is afforded of a tubercular ornament of the scales, similar to that of the cranial shield.

Cephalaspis magnifica, the largest representative of the genus at present known, may be readily distinguished from all previously described species. It is the only species besides *C. Campbelltownensis,* Whiteaves, which has a pointed snout, but this pointing is not nearly so prominently developed as in that Canadian form. The orbits are also proportionally smaller and farther apart than in *C. Campbelltownensis,* and the cornua, instead of being long and curved, are comparatively short and broad-based.

The above-described specimen is not merely a unique example of a new species of fossil fish, but, as mentioned at the beginning of this paper, it constitutes the first recorded occurrence of a fish of the family Cephalaspidæ in the rocks of the Orcadian area of Old Red Sandstone. But the discovery of a species of *Cephalaspis* in the Caithness Flags has no important bearing on the question of the age of the Lower Old Red Sandstone of this area, relative to that of the "Caledonian" area of Central Scotland, or of the "Welsh" area of the West of England and adjoining parts of Wales. For the occurrence of another species of *Cephalaspis* (*C. laticeps,* Traq.) in the Upper Devonian rocks of Canada,[1] shows that the genus continued to exist until far on in that great epoch of the world's history.

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[1] R. H. Traquair in Geol. Mag. (3), 1890, vol. vii., p. 16.

But the specimen is of great interest in its bearing on the question of the imperfection of the Geological Record which a few writers seem even yet to be desirous of minimising. It is well-nigh seventy years since the fossil fishes of the Old Red Sandstone of the north of Scotland began to be assiduously collected,—for Sedgwick and Murchison's paper, in which Caithness ichthyolites were first figured, was published in 1828.[1] But the labours of Traill and others in Orkney—of Sedgwick and Murchison, of Dick, and of C. W. Peach in Caithness—of Hugh Miller, Stables, Malcolmson, Duff, Lady Gordon Cumming, and others along the shores of the Moray Firth, did not, during these sixty-five years now concluded, disclose a single relic of any Cephalaspidian in the rocks in question, and people were naturally left to believe that no fishes of that family existed in the waters in which they were deposited.

Suddenly and unexpectedly, however, during the past summer a *Cephalaspis* is discovered in the Thurso district, and in a quarry which had been worked for paving-stones for at least thirty-five years. Only one single specimen, too, is found, but it must have had parents, and relatives, and ancestors. Where are they?

EXPLANATION OF PLATE VII.

Fig. 1. *Cephalaspis magnifica*, Traq.; one-third natural size.

Fig. 2. Tuberculation of the surface at the margin of the orbit; magnified 3 diameters.

Fig. 3. Finer tuberculation of the surface; magnified 3 diameters.

Fig. 4. Pseudo-tessellation of the middle layer of the shield; magnified 2 diameters.

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[1] On the Structure and Relations of the Deposits contained between the Primary Rocks and the Oolitic Series in the North of Scotland—Trans. Geol. Soc. (2), vol. iii., pp. 125-160, plates xiv.-xvii.

XVIII. *Obituary Notice of the late George Brook, F.L.S., F.R.S.E.* By WILLIAM E. HOYLE, M.A. (Oxon.), F.R.S.E.

(Read 17th January 1894.)

George Brook was born on March 17, 1857, of Yorkshire descent, and was a typical example of the sturdy independence characteristic of that county. He was educated at the Friends' School, Alderley Edge, and in 1873 entered as a science student at the Owens College. His love of natural history was innate, and when he left college it was not to discontinue his studies, but only to prosecute them with undiminished ardour. Though actively engaged in business in Huddersfield, he devoted his leisure hours to botanical and zoological researches, in conjunction with the late Mr J. W. Davis and other kindred spirits. Among the earliest of his investigations were those on the Collembola, some results of which are embodied in communications to the Linnean Society in 1882 and 1883; and it is interesting to note that his final act, as a zoologist, was the determination of one of these insects for his friend Professor Herdman. For some years he maintained, with conspicuous success, a marine aquarium at his inland home, some of the general results of which were given to the world in his "Notes from my Aquarium," and in the first paper he read before this Society, "On the Aëration of Marine Aquaria"; whilst his papers on the development of the Lesser Weever Fish, and of *Motella mustela*, read before the Linnean Society in 1884, demonstrated the fact that his tanks were not the toys of an amateur, but instruments of scientific research. These investigations upon fishes led to his being invited in 1884 to come to Edinburgh as scientific assistant to the Scottish Fishery Board. During his connection with that body he accumulated stores of information as to the habits and life-history of various food-fishes, and used his opportunities to collect material for the continuation of his memoirs on the embryology of teleostean fishes. The most important result of this work was the independent, though not the earliest, establishment of the origin of the endoderm from the periblast. This was announced in the *Quarterly Journal of Microscopical Science* in January 1885, and confirmed in several papers contributed to this Society and to the Royal Society of Edinburgh.

Other memoirs written about this time are systematic, such as the revision of the genus *Zeugopterus* and of the sucker-fishes *Liparis* and *Lepadogaster*, whilst others are of more general biological interest, as, for example, the elaborate inquiry into the restoration of lost parts in certain Crustaceans.

The Crustacea were always a favourite group with Brook, and it was at one time his intention to have devoted a large part of his time to their study. The proposal of Dr John Murray that he should investigate the Antipatharia collected by the "Challenger," however, turned his attention to the Cœlenterates. The report upon this group, published among the zoological results of that memorable voyage, was a work of great and lasting importance. Not only did the author clear up many complicated questions of systematic interest, but his morphological work upon the homology of the mesenteries in Antipatharia and Alcyonaria, and the discovery of the peculiar dimorphism in *Schizopathes*, were of even greater importance. These researches led to the beginning of his last and greatest work, the "Catalogue of Madreporaria in the British Museum." Only one volume had been published when the gifted author was called from among us, but it is a work of inestimable value. The name "Catalogue" by no means indicates its scope, for it deals not merely with the British Museum collection, but is an exhaustive monograph of all the species known to exist. For the purpose of its preparation Mr Brook visited the more important museums on the Continent, in order to examine the types of Lamarck and others, and it is no secret that the work could only have been accomplished by a man of independent means, who was prepared to make it a labour of love.

Such is a very brief epitome of George Brook's scientific work, but there are other aspects of his career to which we must turn. A lecturer on embryology in the University of

Edinburgh, he was a successful teacher, and by dint of hard work and considerable self-sacrifice, created a most efficient department. To this Society he was a firm and constant friend—elected a Fellow in 1885, he was placed on the Council in the following year, and elected a Vice-President in 1888.

As a scientific worker he was enthusiastic and conscientious; he drew his conclusions with caution, but was ready to defend them vigorously. He was a genial comrade, but only those of us who had the privilege of long-standing friendship with him knew the warmth and sincerity of his affection.

XIX. *Obituary Notice of the late Charles Jenner, F.R.S.E.*

By J. G. Goodchild, F.Z.S., F.G.S., Vice-President.

(Read 17th January 1894.)

Mr Jenner was born in Kent, went to school there for a few years, left England in his early teens for the north, there entered into business, and, eventually, built up one of the most important commercial concerns to be found in any part of the kingdom. Practically Mr Jenner was a self-educated man, as by far the greater part of what he knew was acquired during the intervals between business hours; and it is as well to remember that in those days self-tuition was by no means the comparatively easy matter that it is now.

All this implies that he was a man of strong will, energetic, enterprising, and business-like, and that he was clear-headed, observant, and shrewd, beyond the ordinary run of men. It implies also that he possessed, largely, the power of bearing great numbers of facts in mind, and of being able to marshal those facts in such a manner as to frequently base sound generalisations upon them.

Mr Jenner's real education may be said to have commenced when he began to travel for commercial purposes. These led him to visit, year after year, many different parts of this kingdom, and eventually took him repeatedly to many of the best-known cities on the Continent. He appears to have been always an observant man, and he was not long in turning the opportunities afforded by travel to good account. By degrees he developed a taste for art, especially for sculpture, and for architecture. He became more and more interested in literature; and, eventually, he contrived to gain no small amount of knowledge of various branches of science.

As soon as his income permitted, he obtained the best oral instruction his means at the time could command, and as his memory was particularly retentive almost up to the day of his death, he acquired a good general knowledge of a wide range of subjects.

In science, it is well known that Mr Jenner had long taken considerable interest in botany. Indeed, he knew a great deal about the structure and the life-history of certain branches of the Cryptogams some years before that part of the subject had begun to attract much attention in this country. His interest in the lower forms of vegetable life continued until after he was turned eighty, and I know that he made the best endeavour failing eyesight would permit to read through the last English edition of Sach's "Botany," which he did with his microscope beside him. Every visitor to Easter Duddingstone Lodge must have been more or less delighted with the wonderfully fine botanical garden he had made there. It was for a long time, and perhaps it is still, one of the best of its kind in existence. Mr Lindsay and others have already described this in some detail, and therefore no more need be said on this occasion.

Amongst other sciences, Mr Jenner for several years took much interest in geology. He used to take oral instruction in the field from the best teachers he could attract to himself, and, as he was above all things a practical man, nothing short of seeing and judging of geological facts for himself would ever satisfy him. He was a man of whom it may fairly be said that he carried originality sometimes to an extreme. This was true of him in his science work as much as in the ordinary affairs of everyday life. Little wonder need be felt under these circumstances if a man who had been always accustomed to observe, think, and act for himself, occasionally arrived at conclusions different in many respects from those reached by his more steady-going contemporaries. Still, although one could not always agree with him in the views that he had thought out for himself his conclusions always repaid attentive consideration. They not only possessed the charm of originality, but they were almost always, good broad generalisations, which, if not in every case sound, yet enabled those who grasped them to take a wider, better, and more comprehensive view of the subject to which they happened to relate.

During the last five or six years his attention had been much attracted by the discoveries relating to the geological structure of the north-west Highlands of Scotland, which have formed the subject of various communications by Professor Lapworth and the working staff of the Geological Survey of Scotland. Many people with good brains fail even now to grasp the full meaning of the complicated structures referred to, but my geological friends who knew Mr Jenner will bear me out in the statement that this old man of eighty-four had got all the broader features of that marvellous piece of geological history thoroughly in mind. For this he was, it is true, largely indebted to the teaching of Professor Lapworth and Mr Peach themselves.

From the geological history of Sutherland he turned his attention to that of the central Alps, with whose topography his travels had made him familiar. One of the last visits I paid to the house was for the purpose of discussing with him some of the more interesting passages relating to the geology of the Alps in Heim's "Mechanismus der Gebirgbildung," of which book he was particularly fond.

Although Mr Jenner latterly did but little original scientific work himself, yet both individuals and societies engaged in research ever found in him a warm and helpful friend.

XX. *Achanarras Revisited.* By R. H. Traquair, M.D., LL.D., F.R.S.

(Read 20th December 1893.)

In December 1889 I first brought the subject of the fossils found in the Old Red Sandstone at Achanarras Quarry in Caithness before the Society, but not having at that time visited the locality, I judged it better to defer publication of the paper. In August 1890 I proceeded to Achanarras along with my friend Mr John Gunn, now our Secretary, and having seen the place, and hunted for fossils among the débris, as well as having received for the Museum a donation of specimens from the Caithness Flagstone Company, I revised my previous paper and published it in the *Annals and Magazine of Natural History* for December of that year. In that paper I recorded the occurrence there of thirteen species of fossil fishes, of which some had not previously been found in Caithness, while one, which I named *Palæospondylus Gunni,* was new to science, and of the greatest interest from a zoological point of view.

Again in 1891 I visited the quarry, and from material then collected, supplemented by specimens obtained from Mr Donald Calder of Thurso, I furnished the Society with a paper, entitled, "A Further Description of *Palæospondylus Gunni,*" which was published in the last fasciculus of our *Proceedings.*

But it was not till the summer of the present year that I had the opportunity of seeing the quarry being actually worked, and pumped clear of water, which in ordinary conditions covers the "bottom" rock, in which the fossils are most abundant. Here I must return my best thanks to the directors, secretary, and managers of the Caithness Flagstone Company for the kindness with which they afforded me every facility for examining the rocks exposed in the section; and to the Company the Edinburgh Museum is also indebted for another large donation of fossils, both from Achanarras and from Spital, those from the last-named locality including the unique specimen of *Cephalaspis magnifica,* which I have just brought before you in a separate paper. The results of this last visit to Achanarras form the subject of the presen communication.

The Hill of Achanarras is a low, gently-sloping elevatio attaining a height of 392 feet above the sea-level, an

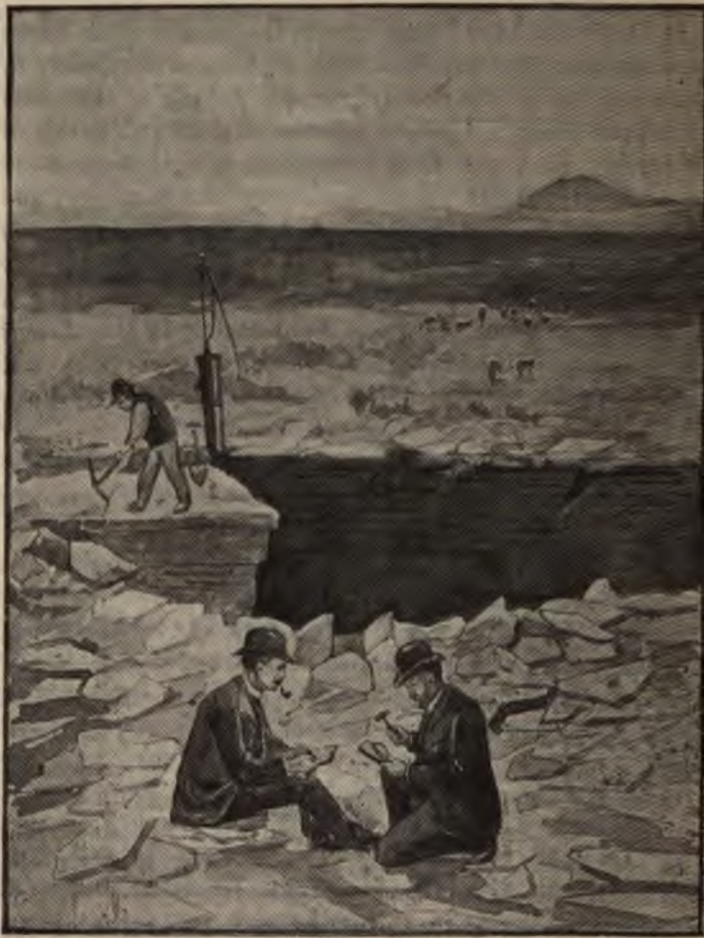

Fig. 1.

South end of Achanarras Quarry, looking S.S.W. towards the Morven Mountains. From a sketch by Mr W. Smith.

situated about 3 miles to the south of Halkirk. Not fa from its flattened summit, on the western side, lies the quarry, the distance of which to the well-known pavement quarries at the base of the somewhat higher Hill of Spital is rather more than a mile in an easterly direction. Here we are just over the border-line which separates the more or less cultivated region of the north-east of Caithness from the bare moorland of the south-west; and the accompanying sketch (Fig. 1), from the pencil of my friend Mr W. Smith, gives a vivid idea of the appearance of the district between Achanarras and the Morven Mountains on the borders of Sutherland. Of these the high one on the right is the well-known Morven itself, and the distance from the quarry to its base is not less than 18 miles, yet it is hard to imagine a scene of more monotonous desolation than that which the low flat stretch of intervening country presents to the eye. Nearly all is Old Red Sandstone; even the summit of Morven is composed of the lowermost conglomerate of the Caithness series, though its base consists of crystalline rocks.

From Mr Shearer, of the Bank of Scotland, Thurso, I learn that the quarry was first opened about the year 1870, by Mr James Munro, farmer at Achanarras, for the purpose of obtaining stones for fencing and farm buildings; but shortly afterwards it passed into the hands of the Thurso Flagstone Quarrying Company, which a few years ago was reconstituted as the Caithness Flagstone Company, the present lessees. It has never been worked for the purpose of obtaining street paving-stone, as the flags into which the rock divides are far too thin. For roofing-slate the stone is also too hard and refractory—difficult to cut, and impossible to "hole." Achanarras slates must therefore, if used, be *notched* on either side, and fastened each with two nails instead of with a single one, as in ordinary cases.

The vertical thickness of rock exposed in the part of the quarry which I saw in working operation amounts to a little over 8½ feet, and the beds, which dip so gently to the east as to be nearly horizontal, may be indicated in the accompanying diagrammatic section (Fig. 2).

The uppermost bed (A), about 4 feet in thickness, is much weathered, and divides into comparatively thin laminæ, each ⅙ to ⅛ inch in thickness, the partings being very ochreous.

When broken across, their laminæ are found to be very hard internally, and bluish-grey in colour.

The second bed (B), measuring about 2 feet vertically, consists of very hard pale bluish-grey flags, usually about 1½ inch in thickness, and also showing ochreous partings. These flags, when newly taken out, are very hard and difficult to split, but when exposed for some time on the heap, they become rusty and crumble away along the edges, while the weathering also tends to eat inwards, so as ultimately to split the whole up into thin rusty laminæ, like those of the upper bed A. The difference between the two beds may therefore be only one of degree of weathering.

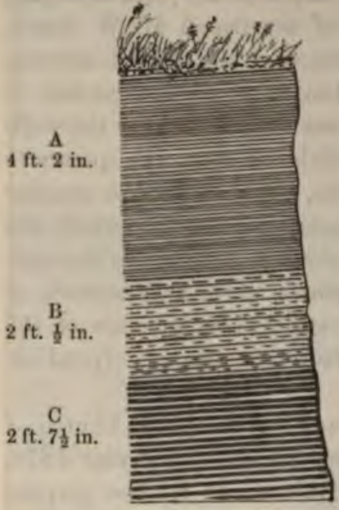

Fig. 2.

Diagrammatic section of the beds exposed in Achanarras Quarry; scale ¼ inch to a foot.

Thirdly, the "bottom" bed (C) consists of about 2½ feet of rock, of a darker colour than that which lies above, and which in the first place naturally divides into large broad flags, usually from 1¼ to 2 inches in thickness; but these, by application of hammer and chisel, readily split again into thinner layers, of which the thickness is only from ¼ to ¾ inch.

From its dark colour this bottom rock is often called by the workmen the "black" rock, and, indeed, the partings are often so dark as nearly to merit that name, though, when broken across, the colour of the slabs internally is more of a bluish-grey of varying depth. In weathering, too, this rock behaves very differently from that of the superincumbent beds, as it does not readily disintegrate on exposure, or become rusty or ochreous; on the contrary, it retains its hardness in spite of rain and sun, while the surface becomes of a light, often yellowish-grey, in fact a dirty cream colour, while exposed bones and scales, black at first, frequently become pale blue, as in the well-known case of the Banniskirk fishes.

Throughout the whole thickness the rock is abundantly micaceous, the mica being in very minute grains. And while the upper beds show by their weathering a large amount of iron in their composition, the presence, in the bottom rock, of a good deal of lime is indicated by a very decided effervescence on the application of an acid.

Finally, in addition to the beds noted above, several feet of dark crumply flags were explored last summer in one part of the quarry, their position indicating that they passed below the so-called "bottom" rock (C). They contained no fossils, and as I did not clearly see their junction with the beds above, I have left them out of the diagram.

FOSSILS.

The fossils occurring in this quarry consist of plants and fishes, but the former are rare, and in so poor a state of preservation, that it can scarcely be possible to identify them.

Fishes and fish-remains occur throughout the whole thickness of the beds A, B, and C, below which quarrying operations are not ordinarily carried. They are, indeed, scanty in the uppermost fissile layers (A); in the hard pale flags (B) they are more common, and principally represented by *Coccosteus;* but it is in the bottom bed (C) that they are most abundant, and in the best state of preservation. There all the species in the list occur almost indiscriminately, but *Palæospondylus* seems to be especially characteristic of the upper part of this bed, beginning to appear about 6 feet from the surface, while *Dipterus* is more especially common in the lower part. I have said in my previous paper that I know of no other fish-bearing schist in Caithness which has precisely the external characters of any of the varieties seen in this section; and taking also into account the appearance of the fossils themselves, it is not difficult, in examining collections, to point out specimens from Achanarras, even if the locality be not marked.

And if the appearance of the fossils is characteristic, so, also, is the following list of species:—

Palæospondylus Gunni, Traq.
Diplacanthus striatus, Ag.
Rhadinacanthus longispinus (Ag.).
Mesacanthus sp.
Cheiracanthus Murchisoni, Ag.
Pterichthys Milleri, Ag.
,, *productus*, Ag.
,, *oblongus*, Ag.
Coccosteus decipiens, Ag.
Homosteus Milleri, Traq.
Dipterus Valenciennesii, Sedgw. and Murch.
Glyptolepis paucidens (Ag.).
Diplopterus Agassizii, Traill.
Osteolepis macrolepidotus, Ag.
Cheirolepis Trailli, Ag.

It will be seen that I have added *Pterichthys productus* and *Pt. oblongus* to my previous list, but the question as to whether these are distinct species, or only forms of *Pt. Milleri*, remains as I left it in a former communication.[1] It is certainly interesting, now to find all three occurring together at Achanarras, just as they do in the Moray Firth nodules.

It would be going beyond the scope of the present paper to enter into a detailed examination of the distribution of fossil fishes in the Caithness area; moreover, the subject is not yet thoroughly worked out. Nevertheless, a few remarks on the list given above may here be hazarded.

No such assemblage of fishes has been hitherto recorded from any other part of Caithness. It differs, of course, from the peculiar fish-fauna of John o' Groats, where the prevailing forms are *Microbrachius Dicki* (C. W. Peach), *Dipterus macropterus*, Traq., and *Tristichopterus alatus*, Egert. Of other localities or districts in Caithness, the only one whose fossil fishes are sufficiently worked out to admit of detailed comparison, is the Thurso area, which occupies so much of the north-west, and extends southwards certainly as far as Halkirk.

The following is a list of the fishes of this area, which I have identified after several years careful study of specimens collected by the late Messrs Hugh Miller, John Miller

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[1] R. H. Traquair, On the British Species of Asterolepidæ—Proc. Roy. Phys. Soc. Edin., vol. xi., pp. 283-286.

(including Robert Dick's specimens), and C. W. Peach—as well as by Messrs J. Reid, W. Tait Kinnear, and D. Calder.[1]

Homacanthus borealis, Traq.
Rhadinacanthus longispinus (Ag.).
Mesacanthus Peachi (Egert.).
Cheiracanthus sp. (perhaps 2 species).
Coccosteus decipiens, Ag.
„ *minor*, H. Miller.
Homosteus Milleri, Traq.
Dipterus Valenciennesii, Sedgw. and Murch.
Glyptolepis paucidens (Ag.).
Thursius macrolepidotus (Sedgw. and Murch.).
Thursius pholidotus, Traq.
Osteolepis microlepidotus, Pander.
Scales doubtfully resembling those of *Gyroptychius*.

Here we have undoubtedly a number of species also found in the list from Achanarras, these being *Rhadinacanthus longispinus* (Ag.), *Coccosteus decipiens*, Ag., *Homosteus Milleri*, Traq., *Dipterus Valenciennesii*, Sedgw. and Murch., and *Glyptolepis paucidens* (Ag.)—probably, also, *Cheiracanthus Murchisoni*, Ag.—while the *Mesacanthus* of Achanarras *may* be *M. Peachi*, Egert. But we have also *Coccosteus minor*, H. Miller, *Osteolepis microlepidotus*, Pander, *Thursius macrolepidotus* (Sedgw. and Murch.), and *Thursius pholidotus*, Traq., species which do not occur at Achanarras, and are also, apparently, absent both from the Orkney beds and those of the shores of the Moray Firth. On the other hand, Achanarras gives us, besides the unique *Palæospondylus Gunni*, Traq., also *Pterichthys Milleri*, *productus*, and *oblongus*, Ag., *Osteolepis macrolepidotus*, Ag., and *Cheirolepis Traılli*, Ag., which have certainly been found nowhere else in Caithness, and we also have *Diplacanthus striatus*, Ag., and *Diplopterus Agassizii*, Traill, of whose occurrence in other parts of the county I have never been able satisfactorily to convince myself.[1] But these are exactly species which are abundant both in Orkney and in the Moray Firth nodules, so that, strange to say, the Achanarras list reads more like one from either of these regions than from Caithness, at least as hitherto known.

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[1] It will here be seen that I have put aside the localitated list of Caithness fossil fishes, given by Sir A. Geikie in his paper On the Old Red Sandstone of Western Europe (Trans. Roy. Soc. Edin., vol. xxviii., 1878), but this involves no disrespect to the memory of my deceased friend, Mr C. W. Peach, by whom the list was principally compiled. For at that time, sixteen years ago, we knew very much less about the generic and specific characters of the Old Red Sandstone fishes than we do now; in fact, the "Systematik" of the subject was pretty much in a state of chaos, and it was not until ten years afterwards that I first attempted to put some order into this chaos, in my paper, Notes on the Nomenclature of the Fishes of the Old Red Sandstone of Great Britain—Geol. Mag. (3), vol. v., 1888, pp. 501-517. A new list remains yet to be published.

As the fishes which are peculiar to this quarry, so fa as Caithness is concerned, are not found even at the localitie for fossils which are nearest to Achanarras, namely Spital Banniskirk, Westerdale, and Achalibster, it follows tha peculiar interest must attach to the exact stratigraphica position of the beds in which they do occur. This is problem which it is, however, best to leave in the hands o the officers of the Geological Survey.

XXI. *River Temperature.* Part I. *Its Daily Changes an Method of Observation.* By H. B. GUPPY, M.B [Plate VIII.]

(Read 17th January 1894.)

When some time ago I accepted the invitation of th Secretary to prepare a paper for the Society on the temperature of rivers, I set busily to work with his assistance t supplement my own observations on the Thames with thos of observers on other rivers. The result was, that in tim my note-books were filled with ideas and facts; but, as th inquiry proceeded, the ideas disappeared and the facts alon remained, and I found myself face to face with a proble that demands, even for a preliminary investigation, a vas amount of labour, and for its ultimate solution, a very muc more uniform line of research. Uniformity of method i sadly lacking in the work of all observers, my own included and one of the first requisites is, by a careful study of th daily thermal regime of a river, to bring all these data int line. The most pressing want of the future is to devise a mode of investigation generally applicable in different parts of the world; but the choice should not be directed by any discussion of the physical aspects of the problem—our only plan, it is true, when the inquiry was first begun, but now out of place with an abundant experience to guide us. The least profitable path has been that of the speculator, whilst most progress has been made by the systematic plodding of the cautious investigator.

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[1] This, as regards *Diplopterus*, will appear a strange statement to man who are familiar with Hugh Miller's writings, but there can be little doub that the Thurso "*Diplopterus*," whose cranial buckler is figured in th "Footprints," is *Thursius pholidotus*. *Thursius macrolepidotus*, too, ha often done duty for "*Diplopterus*," as well as for "*Osteolepis*" *macrolepidotu*

I am not fitted to distinguish between one observer and another in these matters, but two names occur to me as I write, that of M. Renou, the eminent French meteorologist, in connection with the Loir, and that of Dr Griffith, of the East India Company's Service, in association with the Brahmaputra. The work of each is a model of patient observation, but in different fashions: Renou's observations covered years, and are invaluable; those of Griffith occupied only a month, and derive part of their importance from their locality; in truth, the first warm corner for the controversialist will be found in the behaviour of the Brahmaputra in the valley of Assam.

A more or less accurate acquaintance with the diurnal changes of the temperature of a river will, as I have above indicated, clear the ground of a good many preliminary difficulties. At present, however, only the material that has been fairly well digested will be employed, and it must be borne in mind that many important series of investigations have thus been passed over. The range of temperature during the cycle of the year cannot be here discussed, though the subject is linked closely to the one now under consideration. The material for its study is far more abundant, and in fact quite nine-tenths of the series of observations on river temperature are barren of information on the daily changes.

It is first requisite to know whether a river preserves the same temperature in mid-stream and at its margin, and whether the temperature alters with depth. Renou informs us, with regard to the Loir at Vendôme, that the mean temperature of the borders and other parts of the river differed only a few hundredths of a degree Centigrade. Dr

A. von Danckelman, writing of the Congo at Vivi, remarks that the temperature at the surface varied only some tenths of a degree (C.), whether in mid-current or at the banks. Dr W. Griffith, in the case of the Brahmaputra at Sadiyá, found scarcely any difference between the temperatures of the water near the banks and some distance out in the stream. There is no doubt that in the instances of large swift rivers like the Congo and the Brahmaputra there would be scarcely any marginal heating, and the same remark would apply to rapid rivers of much smaller dimensions.

In the case of the Thames, usually a sluggish river, as I should observe, I found that the marginal shallow waters capable of being superheated to any marked extent lay out of the current, as in the eddies or backwaters, where the water is sometimes nearly still. They extended only a few feet from the shore, and had a depth only of a few inches, forming in fact a very insignificant proportion of the river's bulk. In spring these marginal shallows were warmed two or three degrees (F.) above the temperature of the mass of the river when the day was sunny—during a hot summer afternoon the difference was from four to six degrees. Thus on a warm July day, when the temperature in mid-stream was 70° (F.), the thermometer, placed in water 1½ inch deep and a foot from the shore, registered 76°; 2 feet farther out, in a depth of 3½ inches, it showed 73°·5; and some 6 feet from the shore the temperature was nearly that of mid-stream. These marginal shallows had in summer a much greater daily range of temperature and a higher daily mean than the bulk of the river possessed. With an excess of from four to six degrees during the day, they became one or two degrees cooler at night. Thus between the afternoon of July 7th and the following sunrise, whilst the air in the shade fell in temperature from 86° to 65° (F.), and the water in mid-stream from 71°·8 to 71°·1, the marginal shallows, where they were 2 inches deep, cooled from 75°·5 to 69°·5, their mean of 72°·5 being one degree higher than that of the centre of the stream. These remarks apply only to the marginal shallows out of the current. Let these shallows be more or less in the current, and the difference between their temperature and that of the mass of the river in great part, if not altogether, disappears.

Although such marginal heating may form an insignificant feature in the thermal economy of the Thames, it can readily be perceived that in the case of a much larger river bordered by extensive shallows, this phenomenon might be observed on a far greater scale. It ought to be very pronounced in the instance of some tropical rivers. In an inland journey from the port of Guayaquil, during the period of the inundations when the rivers flowed over the vast savannahs, A. von Humboldt sailed on the flooded plains where the water was 4 to 5 feet deep and the temperature 33° to 34° (C.), or 91°·4 to 93°·2 (F.). When we contrast this with the usual temperature given by this traveller for the Orinoco, viz., 27° to 28° (C.), or 80°·6 to 82°·4 (F.), we recognise an important feature in the thermal regime of tropical rivers.

The marginal heating of a river like the Thames, and the superheating of the waters of the flooded plains of a tropical river, are determining elements in the distribution of plants, and it is noteworthy that in the case of the Thames the same causes that favour the heating of the water at the edges favour also the collection of floating seed-drift, a fact of weight in the germination of floating seeds. This is a subject I have been working at for the last three years, and, though full of interest, it can only here be alluded to in passing.

Coming to the question of the uniformity or otherwise of a river's temperature in depth, I append the following data, which go to show that, except in the case of rivers that have an almost imperceptible current, the temperature varies but slightly with the depth. It cannot be said, however, that the data give full precision to this inference, materials relating to great rivers being scarce, and when present often scanty. We can, notwithstanding, accept the general conclusion, based as it is on the testimony of several observers, and leave to time and to research to supply us with particulars.

During the summer of 1834 Professor Merian, of the University of Bâle, found no difference between the temperature of the Rhine at the surface and at a depth of 5 metres. Professor Fournet is my authority for this statement. In 1851 M. Renou, in the case of the Loir at Vendôme, placed the difference of the mean surface and bottom temperatures at a few hundredths of a degree Centigrade, the Loir in this locality being 3 to 5 metres deep. It is observed by Lieutenant Marr, in the report by Captain Humphreys and Lieutenant Abbot on the Mississippi, that the difference between the temperature of the water at the surface and at the bottom was usually so slight as not to be observable with the common thermometer. Unfortunately the heads of this famous survey regarded the systematic observations made for two years and more on the temperature of the river as too purely scientific in their interest to embody in any detail in their report. Coming to the Weser, we find similar evidence in the paper of Herr von Freeden, wherein he gives the results of ten years' observations on that river at Elsfleth, near Bremen. On account of the mixing of the water, the temperature, he says, is the same in all depths. At this locality the tidal influence is strong, just as we find in the case of the Thames at Greenwich, the scene of a famous series of observations covering thirty-three years, which have been discussed by Sir George Airy.

Amongst the most important observations bearing on this subject, which have hitherto come under my notice, are those made in August 1876 by Captain E. Borius and Dr Louvet during their ascent of the Senegal to the cataracts of Felou, about 500 miles from the sea. In connection with river temperature, I shall have frequently to refer to this expedition, which was organised mainly for the purpose of making meteorological observations on the river. Its promoter was Dr A. Borius, who was especially anxious to supply information concerning tropical rivers, the lack of which had been recently deplored by M. Renou. These systematic observations, which go to show that in respect of temperature with depth the Senegal presents no exception to the general rule, were made usually several times daily between 6 A.M. and 8 P.M., both at the surface and at a depth of 5 metres, which was half the usual depth of the river. From the means of the observations, Dr Borius infers that the surface was 0°·4 (C.), or 0°·7 (F.), cooler than the water 5 metres deep. On carefully going over his figures, I make the surface on the average only 0°·05 (C.), or 0°·09 (F.), cooler than the greater depth. The difference, however, is in either case small, and it is scarcely worth while at present to discuss its nature or its origin. From an analysis I have made of these results, I gather that at 6 A.M. the surface was cooler by one- or two-tenths of a degree Centigrade, whilst at 10 A.M. it was warmer to the same extent. The comparisons varied much at noon and at 4 P.M., the difference being sometimes an excess of one- or two-tenths for the surface, or of two- or three-tenths for the greater depth, whilst occasionally the temperatures were the same. At 8 P.M., either the surface was a couple of tenths cooler or there was no difference at all. We thus see that the surface-heating, when it was apparent, was very slight, and was noticeable only in the heat of the day. The slight coolness of the surface, also not uncommon in the daytime, Dr Borius attributes to the heavy rains which the party at times experienced. On one occasion when the river was 27°·6 (C.), and the air 28°·4, the temperature of the rain proved to be 22°·4.

In the spring of 1885 Dr Marcet made some observations on the temperature of the Lower Nile, and, though unable to obtain any definite results from his experiments, he arrived at the conclusion that, owing to the thorough mixing of the water arising from the winding course of the river, and from the unevenness of its bed, the temperature must have been nearly the same throughout its depth, which was sometimes 5 fathoms and over.

Before proceeding to refer to my own observations on the Thames and its tributaries, I should remark that precise data for great rivers are apparently scanty. We want to know something more of the Congo at Vivi and its reputed depth of 90 fathoms, of the Yangtse with its depth, for instance at Hankow, of 70 or 80 feet, whilst even of the Mississippi my information as yet is only of a general character. We require much to supplement Mr Révy's solitary observation on the

Parana, near Rosario, in the midst of a southern summer, when he obtained a surface temperature of 80° (F.), whilst the thermometer in the shade registered 110°.

Lastly, I give the results of my own observations on the Thames and its tributaries above Teddington Lock. They were made with a thermometer of the Sixe pattern supplied to me for the purpose by Messrs Negretti & Zambra, an ordinary thermometer being, however, used for ascertaining the temperature of the surface inch. Until I could thoroughly trust the Sixe instrument, the following apparatus was employed as a check, which proved eventually to be unnecessary:—Two minimum thermometers were fixed between two wire gratings, such as are used for pressing plants. The instruments were arranged crosswise, so that any jerk or other disturbance would be detected by the different readings of the indices. My apparatus was cumbrous, but in the workshop of a mechanician a handy means might be devised.

My observations on the Thames were made in mid-stream between Teddington and Walton Bridge, and therefore above tidal influence. The results of twelve sets of experiments made between 1 and 4 P.M. in the warm season from May to September were as follows:—On the sunniest days, in depths ranging from 7 to 12 feet, the difference between the surface inch and the bottom varied from 1° to 1°·5 (F.). When the sky was somewhat clouded the difference was only 0°·5. The current was very sluggish during this summer, and was not usually more than half a mile an hour. I may refer particularly to one of these days, as apparently affording very favourable conditions for surface-heating. It was a broiling hot June afternoon, with a cloudless sky, not a breath of wind, the current not half a mile an hour, and the air in the shade at 86° (F.). Four observations gave a constant difference between the bottom and the surface inch of 1°. The temperatures at intermediate depths varied a little in these experiments, the mean occurring sometimes at the middle depth, at other times above or below it.

These differences between the surface and bottom temperatures apply, as I have said, to summer afternoons, and at a time when the river temperature is approaching its maximum; they disappear nearly or completely at night. As the morning advances, the whole bulk of the water gradually heats up, but the surface at a quicker rate than the bottom; in the afternoon, however, the bottom begins to pick up its lost way, and by 8 or 9 P.M. the difference is very small. The bottom reaches it maximum temperature rather after the surface, and falls short of the surface maximum by about half a degree (F.), but both the surface and the bottom have the same or nearly the same minimum at night. That a river should exhibit diurnal fluctuations through its mass naturally follows from the experiments of the several observers, who have found little or no difference between the surface and the bottom temperatures. I have no data for rivers of great depth, but to rivers ordinarily deep this remark applies. Professor Plantamour speaks of the Rhone at its exit from the Lake of Geneva as having a scarcely appreciable diurnal variation at the depth of a metre. My facts go to show that this is not true of rivers generally, and it certainly would not be correct for the Thames or the Senegal, the last-named river displaying diurnal variation at a depth of 5 metres. This subject, however, will be more fitly discussed when treating of the daily changes of river temperature.

In winter, owing to the more rapid current, one would expect the Thames water to be always well mixed, and in fact my experiments gave little or no difference. One December morning, when the surface was 37° (F.), the bottom temperature, where the depth was 11 feet, proved to be not warmer. I got the same result at the end of the month, when the surface was 34°·3, and by carefully carrying out the observation, the possibility of the bottom being more than a small fraction of a degree cooler was excluded. On 8th January 1894, I found at the same place a surface temperature of 33° and a bottom temperature not higher, the river being in great part frozen over. In the afternoon of 4th January 1893, when the air in the shade was 23° (F.), the river having been frozen over for two days, I found in a depth of 10 feet, just above the upper lock-gates at

Teddington, that both at the surface and at the bottom the temperature was 32°. On returning home I tested the correctness of my thermometer in a mixture of melting snow and ice. On another occasion, during this spell of Arctic winter, the water, as it rushed from under the ice down the weir at Teddington, was at 32°. Here it came within tidal influence, but the temperature remained the same, and no difference was to be observed at Petersham after the tide had been running up for two hours. My experiments were prolonged until late in the evening, and as I stood watching the river, with the air at 16°, and almost everything freezing around me except the water, there seemed to be in my surroundings a good deal to emphasise the opinion long since advanced by Weitz, that a river will not freeze solid until the soil is frozen to the depth of its bed. The literature on this subject is, however, already abundant, and a discussion would be foreign to the subject of this paper.

To return now to the question of the surface-heating of rivers, I will assume that it has been well established that rivers of ordinary depth, say 2 to 5 fathoms, have either much the same temperature top and bottom, or show only a difference small in amount. No doubt the more rapid the current of a river, the more frequent and complete will be the mixing process, and a sluggish stream like the Thames will exhibit more surface-heating than a more impetuous river. Small streams, like the tributaries of the Thames, when in summer the water is low and the current very sluggish, present less uniformity in this respect. The Mole, which joins the Thames at Molesey, presents a typical instance. In the middle of May, about Hersham and Esher, in places where the current was scarcely perceptible and the depth from 5 to 9 feet, the difference between the surface and bottom temperatures varied from 2°·5 to 3°·5 (F.). In those small rivers which, in dry summers, shrink considerably, the water becoming semi-stagnant in the deep pools, the surface-heating would be great. Mr A. Harper gives a good example in the Thurso, where in summer the salmon die off in numbers in the heated waters of the slow-running stream, and thrive only where the stream is rapid and sheltered from the sun.

The difference between rivers, and ponds, and pools, with regard to surface-heating, has been remarked by Von Freeden, Fournet, Max von dem Borne, and many others, in its connection with the life of the plants and animals that there thrive. The distinction would be, probably, even more pronounced in the tropics than in the temperate regions. Thus, for instance, Livingstone refers to some pools in Central Africa in lat. 20° S., which in March had a temperature of 100° (F.) at the surface, whilst water deliciously cool could be obtained by walking into the middle, and lifting it up from the bottom. The heated top-waters of these ponds must have had a temperature quite 20° higher than that of the Zambesi in the same time of the year, and by this single comparison an important distinction between ponds and rivers in the tropics is disclosed. Having paid considerable attention to this subject in connection with plant life, whilst contrasting the temperatures of the rivers, streams, and ponds in the neighbourhood of Kingston, I must be excused if I diverge a little from the subject immediately in hand, in order to show that the lack or absence of surface-heating in rivers, in place of being a meaningless distinction, has a very practical significance as regards the germination, flowering, and seeding of water-plants.

In a small pool, in the middle of April, I noticed that the flower-buds of *Ranunculus aquatilis*, which were just submerged, were in water of a temperature of 61° (F.), whilst, 9 inches down, the stems of the plants were in water of a temperature of 46°. At the beginning of May, when the flowers were open, the surface of this pool was 71°, a temperature not attained in the Thames until after the middle of June. My experiments show, that whilst the initial germinating temperature of this plant is below 49°, the production of the flower-bud requires a temperature of about 60°.

In a hot August afternoon, with the air at 86° in the shade, and the Thames at 74°, I found, in the middle of one of the large ponds in Bushey Park, where *Myriophyllum* abounded, a surface temperature of 82°, whilst the bottom, 3 feet down, was 73°. Early in July I observed this plant flowering under closely similar conditions, with a difference also of 9° between the top and the bottom, the surface temperature of 83° being 11° higher than in the case of the Thames. It would seem probable that though *Myriophyllum* is able to flower in the stream of the Thames, it would not often fruit. Though the initial temperature of germination for *Myriophyllum spicatum* proved in my experiments to be as low as 49°, I estimate that it needs a surface-temperature of about 70° to produce its flowering spike. This heat was reached on about twenty-one days in the Thames last summer, the highest reading being 75°.

In the middle of June, in a pond 3 to 4 feet deep, on Oxshott Heath, luxuriant masses of *Scirpus fluitans* were in flower, the upper portions of the plants being in water of a temperature of 82°, whilst their lower parts were in water 11° or 12° cooler. I have noticed *Ceratophyllum demersum* flowering abundantly in rivers like the Lea, but never in mature fruit, and after a careful comparison of my river and pond temperatures, I formed the conclusion that whilst this plant requires an average daily maximum temperature of 70° to produce its flowers, a warmth of 80° and over is necessary to mature its fruit, a condition to be found in this country in shallow ponds, where the plant fruits abundantly, but not in rivers, where they may flower, but do not, as far as I know, mature the fruit. The thermal conditions for the maturation of the fruit occur in our shallow ponds, those for the flowering only are found in our rivers.

Summing up the results of the comparisons of the Thames and the ponds in the vicinity of Kingston during last year I may say that on sunny days the surface-waters of the ponds were, in March, 2° or 3° (F.) warmer than the river in April 3° to 5°, in May and June 6° to 8°, and in July and August 6° to 12°. This goes to explain the fact, that during the past summer the *Limnanth* and the water-lilies of the ponds were, as regards fruiting and flowering, some weeks in advance of those of the river. It is to be remarked that the surface-heating is always more pronounced in a pond full of submerged plants than in one comparatively clear. Pond-plants, to a great extent, regulate the temperature of the waters in which they thrive. Dense growths of such submerged plants as *Myriophyllum*, *Ceratophyllum*, *Zannichellia*, and *Scirpus fluitans*, favour surface-heating by obstructing the circulation of the water, and thus tend to produce the thermal conditions requisite for their flowering and the maturation of their seeds. On the other hand, the floating leaves of the water-lilies and of some of the *Potamogetons* keep the pond cool by day and warm at night. River and pond temperature in warm climates must be often greatly influenced by the floating masses of *Pistia*, *Salvinia*, and other water-plants.

I pass on now to consider the times at which, in the course of its daily fluctuations, a river attains its minimum, maximum, and mean temperatures. With regard to the hour of minimum temperature, most observers agree in their sunrise or early morning observations, but Renou is my principal authority in this matter. From his hourly observations on the Loir from 6 A.M. to 10 P.M., excepting 8 and 9 P.M., he places the hour of lowest temperature at 7 A.M. from April to October, at 8 A.M. in February, March, and November, and at 9 A.M. in December and January. For the Seine at Choisy-le-Roi he states the time to be after sunrise, at 5 or 6 A.M. in summer, and 8 or 9 A.M. in winter. For the Thames at Kingston I found the lowest temperature to be reached at sunrise or during the two succeeding hours. The Arve, the most considerable of the Alpine tributaries of the Rhone, behaves in a peculiar fashion, due probably to its mountain course as well as to its draining a basin, rather over one-tenth of which is occupied by glaciers and perpetual snow. According to Professor Chaix, its temperature in summer continues to fall until 9 or 10 A.M. From the table which Dr Borius gives for the Senegal, it is evident that above tidal influence the coolest temperature occurs not later than 6 A.M. On the whole, I am inclined to think that during the hour after sunrise would be found the most suitable time for observing the lowest temperature of rivers in most parts of the world.

At such a time the water is usually several degrees warmer than the air. In the case of the Thames I have frequently found at dawn a difference of from 6° to 12° (F.). Renou, according to his table of hourly means for the Loir, noticed on the average a difference of 10° or 12° (F.) in summer and considerably less in winter. In the instance of the Saale, near Halle, Dr W. Ule places the difference between the means of the 6 to 7 A.M. air and water observations for the year at 3°·95 (C.), or 7°·1 (F.). During March on the Lower Nile, Dr Marcet found the river at sunrise to be on the average about 14° (F.) warmer than the air. On the Santa Cruz river in Patagonia, Captain Fitzroy observed in April that the water at daybreak was 16° (F.) warmer than the air.

In the tropics, also, the river-water is usually warmer at sunrise. On the Senegal in August Captain Borius ascertained that on the average the river was at 6 A.M. 4°·3 (F.) warmer than the air. Schomburgk on the Essequibo found the water to be generally 8° to 10° (F.) warmer at 6 A.M. Humboldt on the Orinoco noticed in April a difference of about 7° (F.). Wallace on the Rio Negro noticed the average difference in September to be 9°·4 (F.).

These facts may appear to unnecessarily illustrate a well-known feature of river temperature, but I have quoted them to give point to another familiar character of rivers, namely, their "smoking" or steaming in the early morning. The moisture arising from the river is condensed by contact with the cold morning air and forms a white vapour that rolls about on the surface of the water. This phenomenon came very conspicuously under the notice of Captain Fitzroy during the ascent of the Santa Cruz river in Patagonia, when, as before observed, he found the water 16° warmer than the air. It is to be seen on most fine summer mornings on the Thames at Kingston, and is especially remarkable during severe winter weather in the case of small rivers that, owing to their abundant spring supply or to their underground courses, do not freeze, such, for instance, as the Iton in France and the Wandle in England.

The distinction must be made between the steaming of a river and the dense fogs that hang over some large rivers, thinning out as they extend to the country round. These fogs arise from the opposite condition of things; the water, being several degrees cooler than the air, here performs the office of a condenser. Rivers after issuing from the gloomy and rarely sunlit ravines of a lofty range, carry with them for some distance in the plains the chilly temperature of their mountain courses. For instance, the Brahmaputra, after emerging from the eastern Himalayas into the full exposure of the valley of Assam, long retains its coolness, and the fogs and mists that form over its surface mark out its track for 50 miles or more. This I gather from the observations of Dr Griffith on this river at Sadiyá in September 1836. The temperature of the water during the whole month was, day and night, below the air, the difference in the means for the period being 12°·9 (F.). There is no space here to dwell on the manner in which the salubrity of a river-valley may thus hinge on the temperature of a river. It has occupied the attention of many, notably Fournet in the case of the Rhone, and the observations of Griffith will enable us later on to in some measure estimate one element of unhealthiness, namely, the rapid nocturnal air chill.

Coming now to the hour of a river's maximum temperature, I may remark that but few observers seem to have made this a special subject of investigation, though several give sufficient data for an approximate estimate of it. Once again we look to Renou for guidance in this matter. From his hourly observations on the Loir, it appears that the water attained its highest temperature at 3 or 4 in the afternoon in summer, and at 2 or 3 in winter. For the Seine, he places the time of the maximum at between 3 and 4. In connection with the Elbe's tributary, the Saale, Dr Ule remarks that the water is often higher in the evening than at noon, and I would infer that in summer the maximum temperature is reached at an advanced hour of the afternoon. The Arve in summer, according to Professor Chaix, increases in temperature until 9 and 11 at night, an unusual feature, which may be due to the Alpine character of its basin. On the Thames I made numerous observations to determine this point. In summer the maximum is reached between 4 and 6 P.M., and retained up to between half-past 7 and half-past 8 in the evening, when the water begins to cool. In winter, as far as my data show, the temperature begins to fall after 2 P.M. In the spring and autumn the highest reading is obtained between 3 and 4 P.M., and in sunny weather the water does not begin to cool until 5 or 6.

With regard to rivers of warmer climates, Dr Borius, in his table of the Senegal observations, makes it clear that the water reaches its highest temperature generally about 4 P.M. in August, the cooling between this hour and 8 P.M. being usually slight. From Mr Wallace's observations in September on the Rio Negro, and from those of Dr Griffith in the same month on the Brahmaputra, it would appear probable that the former river is warmest between 3 and 4 in the afternoon, and the latter between 4 and 5.

We are now in a position to form an idea of the suitable hour to determine a river's maximum heat. For the temperate regions, in the case of a river of the size of the Thames or the Seine, 4 to 5 P.M. in summer, 3 to 4 in spring and autumn, and 2 in winter, would prove suitable hours. Smaller rivers, like the Loir at Vendôme, where it seems to be about half the size of the Thames at Kingston, should be observed an hour earlier during all the seasons except in winter, when 2 o'clock would doubtless do. Rivers much larger than the Thames and the Seine, such as the Danube and the Volga, would on *à priori* grounds attain their highest temperature in summer not before 6 in the evening, and in the other seasons about 4 or 5 in spring and autumn, and 2 or 3 P.M. in winter. For great rivers in warm climates it is probable that the hour before sunset would afford the most fitting time for observation all the year through.

With regard to the time when a river reaches the mean temperature of the day, Renou's tables give important information for the Loir, and from them we may conclude that the mean temperature is attained at half-past 10 or 11 A.M. in summer, at half-past 11 in spring and probably autumn, and at noon in winter. For the Thames I very roughly estimated that the suitable time would be between

11 and noon. Renou suggested to M. Valin, in the instance of the Loire at Tours, to take his observations at 11. Judging from the tables, which Dr Borius gives for the Senegal, noon was the hour best fitted in August for the purpose. For the temperate zone, the subjoined table, which I have constructed from Renou's Loir tables, will be useful, with the necessary adaptations, for most rivers. It is certainly of importance to learn from its columns that if we employ the same hour of observation for obtaining the mean temperature in winter and in summer, we should be in error, since the hour of the mean in midwinter is the hour of three-quarters range in the middle of summer. The table ought to be serviceable in reducing to the same value the numerous observations on English and Scottish rivers which are contained in Dr Mill's British Association *Report*, observations which, through their having been made at very different hours, are in themselves somewhat difficult of comparison. This difficulty, however, has been made more apparent than real by the tables of Renou, and it is to be hoped that Dr Mill, who has here done for our own rivers what Forster has done for those of Central Europe, will initiate the inquiry again.

Table of the Progress of the Temperature of the Loir at Vendôme during the day, constructed from the tables of M. Renou ("Annuaire Météorologique de la France," 1852).

	Lowest Temperature.	One-fourth Range.	Half Range, or Mean.	Three-fourths Range.	Highest Temperature.
January,	9 A.M.	11.15 A.M	12.15 P.M.	1.30 P.M.	3 P.M.
February,	8 ,,	10.30 ,,	11.40 A.M.	12.30 ,,	3 ,,
March,	8 ,,	10.15 ,,	11.30 ,,	12.45 ,,	3 ,,
April,	7 ,,	...	11.30 ,,	...	4 ,,
May,	7 ,,	9.10 ,,	10.30 ,,	12.15 ,,	4 ,,
June,	7 ,,	9 ,,	10.30 ,,	12.10 ,,	3 ,,
July,	7 ,,	9.30 ,,	11 ,,	12.40 ,,	3 ,,
August,	7 ,,	9.45 ,,	11.20 ,,	12.50 ,,	4 ,,
September,	7 ,,	...	...	...	3 ,,
October,	7 ,,	...	...	...	3 ,,
November,	8 ,,	10 ,,	11 ,,	Noon.	2 ,,
December,	9 ,,	11 ,,	12.15 P.M.	1 P.M.	3 ,,

Tidal influence will probably not affect the regular rise and fall of river temperature very much, as long as it merely results in the to-and-fro movement of the same body of fresh water. There is no evidence of any such interference in the tables which Sir George Airy gives for the Thames at Greenwich, though I can only found this opinion on the similarity in amount of the river's daily range above and within tidal influence, as at Kingston and Greenwich. The unusually limited daily range of the Weser at Elsfleth seems to indicate some direct access of sea-water, though the absence of such an influence is expressly stated. The Senegal at its mouth, off the Island of St Louis, exhibits in August and September very irregular daily fluctuations, and as often as not no rise at all. In this season, according to Captain Borius, the water was potable, but it is apparent that the salt-water had some access, though the mixture was not so noticeable as in other times of the year.

With regard to the diurnal ranges of rivers generally, it is a remarkable fact that great differences in the size of rivers are not represented by great contrasts in the amount of the daily range. I do not here include very small rivers, but those that are not smaller than the Thames, or the Seine, or the Loir, and which may be as large as the Nile. Renou gives for the Loir in March a mean daily range of 1°·0 (F.) and this is just what I have estimated for the Thames in the same month. Dr Marcet's observations give a mean for the Lower Nile in March of 1°·6. In both the Thames and the Seine, according to my own observations and those of Renou the diurnal range is rarely if ever as much as 3°·0, whilst the mean for the year in the case of both rivers is somewhere about 1°·5. These figures strike one as having little relation to the great disparity in size between these two rivers on the one side, and the Senegal and the Rio Negro on the other both of which, according to the observations of Borius and Wallace, would have in the hottest month a daily range of about 1°·3. Then, again, the daily range of the Thames at Kingston is no greater than that of the Brahmaputra at Sadiyá, neither being over 2°.

When, however, we look into the matter, we find that we are really comparing large tropical or semi-tropical rivers with rivers much smaller in size in the temperate zone. Doubtless, this similarity in the amount of the diurnal range for rivers of temperate and warm latitudes, is due in part to the increased heat of the tropics and sub-tropics being counterbalanced by the large size of the rivers, or it may be that it is concerned with the relatively small diurnal range of the temperature of the air in the tropics. There is, however, very little evidence of this last influence in the case of the Nile and the Senegal. Taking the diurnal range as the mean of the rise and fall, the Nile in March, according to Marcet's tables, had a water range of 1°·6 (F.) to an air range of 29°·5; whilst the Senegal in August had a water range of 1°·3 to an air range of 14°, the ratios of water to air being in these cases widely different. Space will not admit of further notice of this subject, which will be subsequently dealt with at length.

As regards the diurnal range of rivers smaller in size than the Thames or the Loir, it can here be noted that after these limits are passed, the amount increases rapidly with the diminution of the river's bulk. The tributaries of the Thames, as far as I have been able to observe them, display a daily range considerably greater than that of the main stream. During the same September day when the Thames ranged 1°·5 (F.), the Hogsmill ranged 3°·7. In the middle of August, when the range of the Thames was 1°·8, that of the Mole was 3°·2, and that of the Ember 15°. At the end of March, when the Thames ranged 1°, Beverley Brook ranged 10°. The dimensions of each stream at the place of observation, together with their proportional ranges, taking the range of the Thames as 1°, are here given.

The Thames and four of its Tributaries.

River.	Dimensions at Place of Observation.		Proportional Diurnal Range.
Thames, . .	Breadth 250 feet.	Depth 10 feet.	1°·0 F.
Mole, . . .	,, 80 ,,	,, 2 ,,	1°·8 ,,
Hogsmill, . .	,, 40 ,,	,, 4 ,,	2°·5 ,,
Beverley Brook, .	,, 14 ,,	,, 8 inches.	10°·0 ,,
Ember, . .	,, 12 ,,	,, 3 ,,	8°·3 ,,

With the Thames tributaries, the Thurso river in the north of Scotland ought to be related in size. From the tables given by Mr J. Gunn in his paper on this river, the mean daily rise for the year comes out at just 2° (F.); but as the morning observations were made between 10 and half-past 10, a good proportion of the rise would not be included: the afternoon observations of between 2 and 3, would in summer be too early for the maximum temperature; and, guided by Renou's data for the Loir, I would place its mean diurnal range for the year at about 3°·5, or more than double that of the Thames at Kingston, which is 1°·5. In summer the contrast would be still greater, and the Thurso's mean diurnal range for June would be about 6°, or quite three times that of the Thames. I may here refer to the Rhone's tributary, the Arve, which, according to the observations of Professor Chaix, has a daily range in summer of 4° or 5°. Then, again, the Kundeel, a small tributary of the Brahmaputra, has a range of 3°·7, which is nearly double that of the main river.

I have assumed above in the case of small rivers and streams, like the Thames and its tributaries, that their diurnal range is regulated in amount by their bulk; but this can only be true in the strictest sense, when the rivers or streams have about the same plane of temperature as well as proportionally similar depths and velocities. First, as regards the plane of temperature, I will take the Mole, which, though not one-tenth of the size of the Thames, will display, when it has a lower day's mean, a range less than that of the main stream. Then, with regard to depth and velocity, the diurnal range of the same stream may vary greatly from these causes in localities only a few hundred yards apart. Thus, within the same twenty-four hours, the Mole, where it was 35 feet broad, 5 feet deep, and very sluggish, ranged 1°·5, whilst a little distance away, where it was 80 feet broad, 2 feet deep, and more rapid, its range was 3°·0. Though the main stream would usually have a smaller diurnal range than its tributary, it may, therefore, happen from any of the three causes above stated, namely, the superior position of its temperature-plane, its shallower depths, and its greater velocity, that the main river has a larger range. An instance of this occurs in reference to the Loire at Tours, and its tributary the Loir at Vendôme. Though the Loire is naturally a larger and also a more rapid river, it has, says M. Renou, a notably greater diurnal range than its tributary. The discounting of size here is evidently due to the greater velocity and shallower depths of the Loire, for though it has a larger sectional area and a much greater water-discharge than the Loir, it is only about half as deep. A rapid current hastens the mixing of the stream, whilst shallow waters, owing to their larger proportion of exposed surface, are heated up more easily during the day, and cool more readily during the night, and both influences have combined in this case to give the larger river the greatest diurnal range.

The subject of the daily fluctuations of a river would be complex enough if it ended here; but there is much beside that is indeed perplexing. Spring-sources add their share to the difficulties; but, as I will show in a later paper, there are many methods, and notably the study of the curves of the monthly mean temperatures of air and water, by which we may detect their influence. By far the most puzzling feature of these daily changes is to be found in the circumstance that, although in temperate regions the river's diurnal range is usually included within that of the air, there are instances in warmer regions where the river exhibits regular daily fluctuations, with its range altogether outside that of the air. The Brahmaputra is a case in point. As shown by the tables of Dr Griffith, its daily range of temperature during September was always outside and below the range of the air. As before observed, after emerging from the Himalayas it still retains its mountain coolness on reaching Sadiyá, some 40 miles away; and there, strange to say, it regularly increases in temperature by day, and as regularly cools at night, though, as illustrated in Plate VIII., the air is warmer during the whole twenty-four hours. Its mean diurnal range is about 2° (F.), whilst that of the air is about 9°.

The opposite state of things may be found in some tropical rivers, where the plane of water temperature is much higher than that of the air, and the range is sometimes outside the air's range altogether. We learn from Schomburgk that the Essequibo is usually 8° to 10° (F.) warmer than the air at 6 A.M., 1° to 2° cooler at 2 P.M., and 2° to 3° warmer at 6 P.M.; whilst it would appear from his observations that the daily rise would be 1° or 1°·5. By expressing these facts in curves for the whole twenty-four hours, we at once perceive what a high plane of temperature this river must possess. Then, again, Humboldt states that at San Borja, in the middle of April, the Orinoco maintained its habitual temperature of 27°·7 (C.), whilst the air ranged from 23°·7 at night to 26° or 27°·5 during the day. In our own ponds in summer, as well as in our rivers, we find a considerably higher plane of temperature than for the air, and it is obvious that we have the same principle at work here as in the tropics. Heated by the sun during the day, and cooled by radiation at night, the temperatures of the air and of the pond and the river range about different means Thus, on August 24th, when the air range was 49° to 74° (F.), and the Thames ranged from 64°·5 to 66°·5, the ponds in Bushey Park ranged from 64° to 72°. The ponds possessed the highest plane of temperature, then the Thames, and lastly, the air, as represented by the means 68°, 65°·5, and 61°·5.

Postponing the detailed treatment of this complex matter of the relation to each other of the air and water temperatures, I come to the question of the influence of the water temperature on the air. This is a matter of practical importance in river observations; but at present I have data only for the effects of water much cooler than the air, as given in the following table:—

The Means of Observations made on the Brahmaputra and its small tributary the Kundeel, at Sadiyá, in September 1836, *by Dr W. Griffith* ("Journal of the Bengal Asiatic Society," vol. v., p. 827). Fahrenheit Scale.

Hour.	Air in House.	Air over the Kundeel.	Air over the Brahmaputra.	Water of the Brahmaputra.	Water of the Kundeel.
6 A.M.	75°·6	75°·3	72°·0	66°·2	75°·5
2 P.M.	83°·9	87°·1	82°·9	67°·6	78°·6
6 P.M.	82°·9	81°·2	73°·8	67°·7	78°·4
Mean[1]	79°·9	79°·8	74°·8	67°·0	77°·2

From this table it appears that the cooling influence of the Brahmaputra on the air over it was but slight during the heat of the day, being at 2 P.M. only 1°. By 6 P.M. the air had lost 9° through the chill of the river, and it is apparent that the cooling was principally accomplished in the sunset hours. The thermal regime of the Brahmaputra is of course very exceptional. Most rivers in different latitudes are warmer than the air at night, and the time at which the chill of the river ought to be most effective would be about sunset, when the air and water temperatures would be usually not far apart; whilst in the heat of the day, when the water is much the coolest, its chilling influence, according to the Brahmaputra observations, would be slight. These remarks certainly apply to the Senegal observations in August, and probably also to those of Dr Marcet on the Nile in March, and no doubt they are true also of most rivers that have a plane of temperature not far removed from that of the air, as in the case of our own rivers. But there are instances where the chilling effect would be pronounced, namely, as regards large rivers that, like the Upper Yangtse, have a relatively low plane of summer temperature in comparison with the air (Blakiston).

The following rules may be formulated from the Brahmaputra table:—To correct for the water's chill the day's mean of air observations made on a large river, add to it two-thirds of its excess over the day's mean of the water temperature. Thus, with a mean water temperature of 60° (F.), and a mean for the air on a river of 69°, the corrected air mean would be 75°. From this table we can also calculate the corrections for particular hours. Thus, for 2 P.M., only one-fifteenth of the excess, and for 6 P.M. as much as one and a half times the excess, must be added; whilst for 6 A.M. the plus correction would be five-eighths. I have here spoken only of large rivers. Air observations on small rivers would probably be but little affected, as long as the air is in motion. Of this the Kundeel affords an example.

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[1] Estimated from the 6 A.M., 6 P.M., and the (computed) noon and midnight temperatures.

In concluding the first part of this paper, I must lay stress on the value of all observations on river temperature. No period ought to be too short for making useful additions to our knowledge of the subject, and I trust that observers in different parts of the globe will take advantage of opportunities that lie at their doors. Three thermometers, properly tested, would be required. For the air a maximum and a minimum thermometer, and for the water an ordinary thermometer of the bath pattern. I have tried some half a dozen different plans of taking the water temperature, but have found none so good as sinking a bath thermometer 2 or 3 feet below the surface and leaving it there two or three minutes. It is essential that the immersion of the bulb should be sufficient, since many thermometers will not stand the test of being drawn up 10 feet in the cold air after standing in water twelve or fifteen degrees warmer than the air, a not uncommon condition of things at sunrise. The instruments made by Negretti & Zambra, on the pattern of those used in the British Navy for sea-temperature, will stand this test. Of course, a good substitute for a bath thermometer can be obtained by fixing an ordinary thermometer in a bottle and reading through the glass. For rapidity, I have often employed a sensitive chemical thermometer that reads in ten or fifteen seconds, placing it in a large bottle of the river water and reading it there. This is an excellent plan when making a series of comparative experiments on the temperature of streams, rivers, and ponds that may be a mile or so apart. For those who may wish to take the temperature at different depths, the Sixe's instrument I employed, and which may be obtained from the same makers, is very serviceable. It also will supply the place of maximum and minimum thermometers, if checked by a standard instrument.

With regard to the times and the frequency of the river observations, daily observations are of course the best, but those made every two or three days will give with fair approximation the monthly mean. The air observations should be made daily, and the maximum and minimum instruments should be read and set at 8 or 9 in the evening and noted for that day, together with the river observations of the same day. If the river's temperature is taken late in the afternoon, an occasional sunrise observation would give its diurnal range. And the more frequent the observations on the diurnal range, the more valuable will be the observer's work. I have previously referred in detail to the hour of observation; the most convenient time will be probably when the river is at its maximum, usually in the middle of or late in the afternoon.

One of the most important, and often the only available, means of comparing rivers, is to be found in the contrast of the curves of the monthly means for the whole year. As ably argued by Dr Ule, the difference between the air and the water means has a fairly constant value, less variable than, and therefore less influenced than the actual temperatures of the air and the water, by the changing climatic conditions from year to year. And from this point of view, an observer, who has never before interested himself in these matters, and whose period of observation may be limited, may be encouraged by knowing that even a single month's work may afford material of great service. This paper would have lacked much without the observations made by Dr Marcet on the Nile and Dr Griffith on the Brahmaputra, though in both instances they cover only a few weeks. In fact, by comparing Dr Marcet's results for March on the Lower Nile with those for the Lower Mississippi by Captain

Humphreys and Lieutenant Abbot, and those for the Yangtse by Captain Blakiston, some valuable data on the effects on large rivers of running with the latitude or the longitude are disclosed. The subjoined comparison will afford an example.

	Air Mean.	Water Mean.	Difference.
Mississippi at New Orleans, in March 1851,	68°·2(F.)	50°·7	Water − 17°·5
,, ,, ,, 1852,	64°·8 ,,	50°·7	Water − 14°·1
Lower Nile, in March 1885, . . .	66°·3 ,,	68°·3	Water + 2°·0

The localities of observation come near to each other both in latitude and in their relation to the same isothermal line, and as might have been expected, the air means are not far apart; but the water means are wide asunder, and whilst the Mississippi, running from the temperate regions towards the equator, is from fourteen to seventeen degrees cooler than the air, the Nile, after coursing away from the equator, is two degrees warmer than the air.

To collect the observations already published, and to encourage observers in this country and in other parts of the world to devote their attention to this interesting inquiry, would, I venture to think, be objects worthy of the efforts of a learned society; and one might humbly suggest to scientific societies in distant places the advantage that might accrue to science from properly directed investigations of this kind. For instance, in the case of the Yangtse, observations at the same time at Ichang, Hankow, Kiukiang, and Chinkiang might with no great difficulty be instituted; at Hankow the temperature of the main river might be compared with that of its tributary the Han, and, as indicated by Blakiston's observations, the changes of temperature produced on the Yangtse by the inflow from the Tungting and the Poyang Lakes would prove well worthy of study. Blakiston remarks that Lieutenant Poole, of H.M.S. "Havoc," whilst stationed at Kiukiang in 1861, made regular observations of the temperature of the river. Abundant materials must occur in the log-books of British men-of-war, but I do not know whether they are in a form available for employment in this inquiry. The Royal Physical Society of Edinburgh has consented to receive any such observations sent in from abroad, with a view to future discussion, as it is expected that a good harvest may thus be reaped in the additions made to knowledge.

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NOTE.—After this paper had been put in type, I learned that Dr Forster, o
the University of Vienna, was going to publish very shortly the results of hi
long studies of the temperature of the rivers of Central Europe. Dr Forster'
previous publication had been known to me only through a short paragrap
in *Nature*. But as I am a more recent student of these matters, I wil
ingly allow him full priority; and whilst claiming complete independenc
and originality for myself in all advanced in this paper, I regard Dr Forste
as the first to treat systematically this important problem.

XXII. *A still further Contribution to our Knowledge o* Palæospondylus Gunni, *Traquair.* By R. H. TRAQUAI Esq., M.D., LL.D., F.R.S. [Plate IX.]

(Read 20th December 1893.)

At the conclusion of my last paper on *Palæospondylu*
(1), I expressed a hope that additional material might soo
turn up to "throw still more light upon the structure of thi
strange relic of early vertebrate life."

My hopes have so far been realised, inasmuch as amon
the numerous specimens which I obtained during my visit t
Achanarras in August last, there are several which completel
alter one's idea of the configuration of the front of the hea
besides explaining some very obscure appearances in tha
region in some of my previously-collected examples. Fro
Mr D. Calder of Thurso I also obtained some additiona

specimens, one of which shows the structure of the tail-fin in a much more perfect manner than has ever been previously observed.

It will be remembered that in my last communication I described the cranium of *Palæospondylus* as consisting of two parts—an anterior, comparable to the trabecular and palatal part of the lamprey's skull; and a posterior, in like manner comparable to the parachordal part and auditory capsules. No differentiated bones could be seen in this cranium, which apparently consisted of calcified cartilage. No trace of jaws or of hyoid apparatus could be seen in any of the numerous specimens examined; but the anterior margin of the head, bearing four pointed cirri, was compared by me to the upper margin of a suctorial mouth. If the creature was of Marsipobranch affinity, and many points in its configuration were highly suggestive of that idea, evidence as to the condition of the nasal organ would have been of the utmost importance; but no evidence on this point was forthcoming.

What the new facts are will now be seen.

Among my new specimens, the most remarkable head is that represented in Pl. IX., Fig. 1, magnified five diameters. It will here be seen that the part which I represented in my former figures as the anterior margin of the head with four cirri, two outer and longer, two inner and shorter, and which I compared to the upper margin of a suctorial mouth, is in reality the lower or ventral lip of a median depression or opening, which is fringed with cirri all round. This opening appears transversely oval, though it may have been so compressed from an originally round shape. Along its ventral margin are seen four cirri (*v.c.*), while the upper margin shows five (*d.c.*), one of which is median. But there are in addition two other and longer cirri (*l.c.*), which seem to arise within the rim of the opening on each side, not from its margin as the others do; and these are evidently the two longer and external cirri shown in my previous figures, as well as in the figures given by Smith Woodward and Dawson (4, fig. 1; 6, fig., p. 285).

Fig. 2 represents a head in a similar state of preservation, but the inner cirri of the ventral margin of the opening are broken away, while those of the upper margin are well shown. In Fig. 3 we have a head in which, though the general form and position of the cirri are indicated, their preservation i still more imperfect, those attached to the dorsal part of th margin having only their extremities exhibited. Again, i Fig. 4 we have the anterior part of another head, in which though the dorsal rim of the opening remains, the ventra one is broken through in the middle, and only scant trace of the cirri remain.

It is now clear that the specimens formerly described an figured by me were imperfect, and that they for the mos part showed merely the ventral margin of this media ring (5, Pl. I., Figs. 2, 4, and 5). And this explain things which, in the specimens then before me, I was quit unable to understand—how, for instance, in Fig. 2 of the las quoted plate, the apparent anterior margin is slightly conve whereas, had it been the upper margin of a *mouth*, as I supposed, it ought to have been concave. On the other hand, i the specimen represented in Fig. 1 of the same plate, it is th upper margin of the opening which remains, the lower havin become quite obscured by crushing and weathering; an herein is found the explanation of the circumstance that th anterior margin of the head in this case projects farthe forward than in the others.

What is the nature of this aperture, with its strange fring of cirri? It cannot be a sucker like that of the larval *Lepidosteus*, which is a mere superficial disk, having its adhesiv papillæ composed of epithelial cells,[1] and which has n resemblance at all to the part of *Palæospondylus* unde discussion, save its position on the front of the head. Th more obvious comparison—and that which is in harmon with the rest of the structure of our fossil—is that with th single nasal opening of *Myxine* or *Petromyzon*. And if thi view be the right one, then *Palæospondylus* is monorhinal, an *is* a Marsipobranch.

Here, however, it must be remembered that both in th Hag and in the Lamprey the nasal canal is continued pas the olfactory organ, and, passing through the basicrania fontanelle, comes into relation with the pharynx, into which it actually opens in the former, while in the latter it ends in a blind sac. But as there is no basicranial fontanelle in *Palæospondylus*, there could have been no posterior nasal canal; so that if we are dealing with a Marsipobranch, we have here a condition which is either more archaic or more specialised than that in the modern representatives of the group, according as in this particular we consider *Myxine* or *Petromyzon* to be the more primitive.[1]

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[1] Balfour and Parker, Phil. Trans., 1882, part ii., p. 385.

Behind the median cirrated opening, the anterior or trabeculo-palatine moiety of the cranium (*t.p.*) is almost invariably so eroded or broken through that the appearances presented would scarcely be readable without the tolerably perfect specimen represented in my former paper (5, Pl. I., Fig. 2), and refigured, more highly magnified, in the present Pl. IX., Fig. 5. Here and in the restored drawing (Fig. 8) it will be seen that the surface external to the median longitudinal groove is divided by a line passing obliquely backwards and inwards from the external angle, and marking off a small lobe (*a.*), which can also constantly be recognised in eroded specimens (Figs. 2, 3).[2] In front of this line the surface shows two depressions like fenestræ (*b.*, *c.*), but perhaps not completely perforated, each of a somewhat triangular shape, the apices of the two converging outwards towards the external angle, their rounded bases directed inwards. The division between these two apparent fenestræ also constantly appears in eroded heads, as a bar directed obliquely forwards and inwards, as is seen in Pl. IX., Figs. 1, 2, and 4.

The bottom of the median groove (intertrabecular space) is not perforated, but solid, and is seen isolated, as an antero-posterior median bar, in Figs. 1, 2, and 3, the raised edges (trabeculæ) being gone. But in Fig. 4 it is itself gone, while remains of the trabeculæ are seen as a thin black streak on each side.

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[1] If the nasal opening and canal of *Myxine* represent the primitive vertebrate mouth, as is maintained by Beard (Anat. Anzeiger, 1888, No. 1, pp. 15-24), then of course the condition in that genus is more primitive than in *Petromyzon*, and in both than in *Palæospondylus*. But morphologists do not seem to be agreed as to which of the two recent Marsipobranch types is the more archaic. (See Howes, 3, pp. 137, 138.)

[2] It may be fancy, but I cannot help in my mind comparing this lobe with the "styliform" or "epihyal" element of the skull of the Lamprey.

I have never, even to this day, seen the dorsal surface of the head of *Palæospondylus;* but to judge from sundry partial impressions, it is clear that in this anterior or trabeculo-palatine portion a median or cranial part was marked off from the palatine by a ridge on each side, and that this cranial part was, behind the nasal ring, widely open above, as in the Lamprey. The lateral or palatal fenestrated portion was distinctly concave above, and here the eye must pretty certainly have been placed.

I have scarcely anything to add regarding the posterior part of the skull, which is presumably composed of the combined parachordals and ear capsules. Constantly, however, in eroded heads, among its remains may be distinguished two oblong pieces converging forwards at an angle near the junction of the anterior and posterior parts of the cranium, as is seen in Figs. 1 and 2. No indication of such a configuration can, however, be seen in the head shown in Fig. 5, where the surface seems remarkably entire and uninjured.

With regard to the problematical pieces x, their morphological signification seems as obscure as before. They could not have been *external* plates, at all events, and may possibly be a remnant of an internal branchial support.

Nothing new can be said of the rest of the skeleton as far as the tail-fin; but here a previously unobserved fact of considerable importance must be noted. The rods supporting this fin I have considered as neural and hæmal spines, as they are apparently continuous with the neural and hæmal arches, but it turns out that in none of my previous specimens were their extremities complete. A specimen, which I obtained last autumn from Mr Donald Calder of Thurso, shows that these rods or spines were considerably longer than they had been represented in any of my figures, and consequently that the fin was so much deeper. But a point of greater importance than their length, is the fact that at least the neural spines are seen to dichotomise twice, just as in the case of the caudal spinous processes, the so-called fin-rays of the Lamprey. In Fig. 6 I have represented a portion of the caudal extremity of this specimen, magnified thirteen diameters. The differentiation of the vertebral centra and arches is in this case obscure, but the spinous processes are extremely distinct, and the dichotomisation of those on the neural side of the axis, which are also the longer, is seen with the greatest ease under a low power of the compound microscope. Not the smallest trace of transverse segmentation can be observed in these rods, or in their dichotomous divisions.

AFFINITIES.

In my first notice of *Palæospondylus* (1) I suggested the idea of a Marsipobranch affinity, an idea which, having been favourably received by Professor Howes and Mr Smith Woodward (3 and 4), I sought to develop still further in my second paper (5). And though the examination of the most recently obtained material has modified as well as added to our ideas on the subject, the result, instead of weakening the probability of the alliance of *Palæospondylus* with the Marsipobranchs, tends to strengthen it up to what one feels tempted to consider a tolerably close approximation to certainty.

Sir J. W. Dawson has, however, expressed himself in favour of a different interpretation of *Palæospondylus*, after an examination of specimens forwarded to him by Mr J. Reid, Blairgowrie. It must, however, be noted that the work (6) in which he alludes to the matter had been sent to press before he had the opportunity of seeing my second paper.

He says: "It is a little creature, an inch to two inches in length, destitute or nearly destitute of bony covering, having a head which suggests the presence of external gills, large eyes, and even elongated nasal bones. . . . One cannot look at it without the suggestion occurring of some of the smaller snake-like Batrachians of the Carboniferous and Permian; and I should not be surprised if it should come to be regarded either as a forerunner of the Batrachians or as a primitive Tadpole."

These observations are accompanied by a drawing, which is original as regards the head, though evidently taken from a specimen in not quite so good a state of preservation as some which it has been my good fortune to secure; the tail is copied from Smith Woodward's figure in *Natural Science* (4, fig. 1). I suppose he interprets as "external gills" the two narrow post-occipital plates (x in the present figures), on which he has drawn certain lines, as if to indicate a sort of tufted appearance, which I certainly have not observed in any of the numerous specimens which I have examined. Whatever may be the morphological signification of these plates, they cannot be external gills. It is also difficult to see where the "elongated nasal bones" come in, unless the author thereby means the two long external cirri, which are given in his figure in somewhat exaggerated proportions.

As regards amphibian affinities, Sir J. W. Dawson's suggestions give us a rather wide range of choice between highly specialised limbless *Stegocephali* and a "primitive Tadpole," which one would expect to be a creature of a somewhat more generalised type. As regards the former alternative, I must confess that I fail to see any sort of resemblance to *Palæospondylus*, except the want of limbs, which is a feature common to many vertebrates of widely separated affinities; while as to the latter, the primordial cranium of a Tadpole bears just the same sort of resemblance, and no more, to that of our little Palæozoic vertebrate that it does to the skull of *Petromyzon*. But no amphibian, adult or embryo, with which I am acquainted shows a median cirrated opening, presumably a nose, in front of the head.

On the other hand, in support of the Marsipobranch theory we have the following facts:—

1. The skull is apparently formed of calcified cartilage, and devoid of discrete ossifications.

2. There is a median opening or ring, surrounded with cirri, and presumably nasal, in the front of the head.

3. There are neither jaws nor limbs.

4. The rays which support the caudal fin-expansion, apparently springing from the neural and hæmal arches, are dichotomised (at least the neural ones), as are the corresponding rods in the Lamprey.

But not only are no jaws to be found, but also no traces of lingual apparatus. It is hard to imagine the absence of the latter in the living state, so that its elements were probably composed of a more perishable material; and here it may be noted that, in the recent Marsipobranchs, two kinds of cartilage enter into the formation of the cranio-facial apparatus, of which one is considerably harder and more solid than the other.[1] In *Myxine* the hard cartilage prevails in the cranium, while the soft variety enters largely into the structure of the hyo-lingual parts. A similar condition may have existed in *Palæospondylus,* the hard cartilage becoming, in addition, actually calcified, and in this way capable of preservation in a schist like that of Achanarras, while the soft utterly disappeared.

The development, in the sheath of the notochord, of ring-like calcified vertebral centra is no bar to the acceptation of the Marsipobranch theory. For in this respect the greatest differences exist in fishes, both recent and extinct, which undoubtedly belong to the same "subclass." The Palæozoic Elasmobranchs were mostly notochordal, so was the Mesozoic *Hybodus,* so is the recent *Notidanus,* but the Carboniferous *Chondrenchelys* had ring-vertebræ, and such modern sharks as *Lamna,* etc., have the centra highly-developed, asterospondylic, biconcave, and calcified. And if the recent Marsipobranchs are, as some suppose, degenerate forms, there is no reason why a Palæozoic representative of the group should not have had differentiated vertebræ, and these, as well as the cranium, also calcified. Here I may refer the reader to the remarks quoted from Messrs Howes and Smith Woodward at the commencement of my former paper on *Palæospondylus* (5, pp. 87, 88; 3, pp. 143, 144; 4, p. 599).

I have now given the facts of the structure of *Palæospondylus* so far as the specimens before me permit, and if my interpretation of the parts exhibited is correct, there seems no escape from the conclusion that the little creature must be classed as a Marsipobranch. The subject is not yet, however, exhausted; the upper surface of the skull, for instance, remains to be described, but again I may express the hope that still further patient search in the quarry o Achanarras Hill will be rewarded by the discovery of materi whereby our knowledge of the structure of *Palæospondylu* will be rendered still more complete.

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[1] W. K. Parker, On the Skeleton of the Marsipobranch Fishes—Phil. Trans., 1883, part ii., pp. 373-457.

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6. Dawson, J. W., *Salient Points in the Science of the Ear* London, 1893, pp. 285, 286. With a figure.

EXPLANATION OF PLATE IX.

The lettering is uniform throughout all the figures. *t.p.*, anterior trabeculo-palatine part of the cranium; *p.a.*, posterior or parachordal pa *a.*, lobe divided off from the anterior part; *b.*, anterior depression or fenest *c.*, posterior depression or fenestra; *n.*, nasal ring; *v.c.*, cirri of the vent margin of the ring; *l.c.*, long lateral cirri; *d.c.*, cirri of the dorsal margi *v.*, vertebral centra; *x.*, post-occipital plates.

Fig. 1. Head of *Palæospondylus Gunni*, seen from the ventral aspect, a showing the presumed nasal ring with its cirri. The rest of the cranium eroded. Magnified five diameters.

Fig. 2. Another head; the two inner cirri of the ventral part of the ri lost; the rest of the cranium eroded. Magnified six diameters. The enti specimen represented of the natural size in Fig. 7.

Fig. 3. Another head still more eroded, but the position of the nas opening indicated by the remains of the cirri around it. Magnified s diameters.

Fig. 4. Anterior part of another head, magnified six diameters. The dorsal margin of the nasal ring with stumps of cirri is seen, but the ventral margin is broken through in the middle.

Fig. 5. A head figured in my former paper (5, Pl. I., Fig. 2), but here magnified up to seven diameters. Only the ventral margin of the nasal ring is seen, with obscure traces of cirri externally on each side. In this specimen the surface of the skull is wonderfully entire and uneroded, but it seems just a little frayed along the margins.

Fig. 6. Part of the tail of the specimen, the anterior part of whose head is represented in Fig. 4, to show the dichotomisation of the neural spinous processes. Magnified thirteen diameters.

Fig. 7. The specimen, natural size, whose head is represented in Fig. 2.

Fig. 8. Restored outline of *Palæospondylus Gunni*, altered from the figure previously given (5, p. 90) in accordance with the present state of knowledge.

XXIII. *On some Fresh-Water Entomostraca from the Island of Mull, Argyllshire, collected by the late Mr George Brook.* By Thomas Scott, F.L.S., Naturalist to the Fishery Board for Scotland.

(Read 17th January 1894.)

During the year 1890 the late Mr George Brook visited a number of small fresh-water lochs in the island of Mull, when several gatherings of invertebrates—chiefly Entomostraca—were collected and preserved. I happened to meet Mr Brook on one or two occasions afterwards, when he spoke of the collections he had made, and offered to hand them over to me for examination if I would arrange to send for them. Having at the time a good deal of other work on hand, I delayed doing so till there was some prospect of my being able to examine and describe them. Owing to the lamented death of Mr Brook last year, I had given up all thought of the collections, but a few months ago Mr Binnie —Mr Brook's assistant—informed me that they were still intact, and that I could have them; and this explains how I have been able to prepare the following report.

The collections having been carefully worked up, the report I now propose to lay before the Royal Physical Society contains a record of the results obtained. I have the more confidence in submitting this communication, because Mr Brook was, for several years, a respected Fello of this Society, taking much interest in its welfare, an also, because the collections are fairly interesting in them selves, and add considerably to our knowledge of the di tribution of the fresh-water Entomostraca of Scotland.

The collections, contained in twelve bottles, repr senting an equal number of separate gatherings, we from the following lochs:—"Swiss Loch," "Loch Uisg "Sheep Loch," "American Loch," "Loch Airdeglais "Middle Loch," and "Loch Squabain." The names of th three lochs—the "Swiss Loch," "Sheep Loch," an "American Loch,"—are probably the local names for som small tarns in the neighbourhood of Loch Uisg, for th names do not occur on the one-inch Ordnance Survey ma of the island of Mull, but I think there can be no doubt their being situated in the vicinity of Loch Uisg, from th circumstance that all four were visited on the same day, vi the 26th February 1890; Loch Uisg is, on the other hand, well known, although comparatively small, fresh-water lo between the head of Loch Buy and Loch Spelve—two of th sea-lochs of Mull. The positions of the various lochs a more particularly referred to in the sequel. With the preliminary remarks I now proceed to notice each of the loc separately, and in the order in which they are enumerated.

1. THE "SWISS LOCH."

As already pointed out, I have not been able to ascerta the position of this loch, but it very probably occurs som where in the vicinity of Loch Uisg. It was visited on th 26th of February 1890, and the only material collected the was a shore gathering, containing very few organisms. Th only Entomostraca obtained were the following two speci of Copepoda:—

Diaptomus gracilis, G. O. Sars; few.
Cyclops serrulatus, Fischer; few.

Both of these are generally distributed throughout th British Islands.

2. Loch Uisg.

Loch Uisg is a little over one and a half miles in length, by about a quarter of a mile in breadth. It is situated almost midway between the south-west end of Loch Spelve and the head of Loch Buy, in a narrow valley that extends between these two sea-lochs. The material from Loch Uisg consisted of a tow-net gathering from a depth of four fathoms, collected on the 26th February 1890. The only Entomostraca obtained in this gathering were a few specimens of

Diaptomus gracilis, G. O. Sars.

3. "Sheep Loch."

The "Sheep Loch" is probably a small loch or tarn in the neighbourhood of Loch Uisg. (On the hills towards the west end of Loch Uisg, and about half a mile to the south of it, there is a small lochan called "Lochan nan Caorach," or (?) the Loch of the Sheep.) The material from the "Sheep Loch" was collected on the same date as the other two, and consisted of a shore gathering. Entomostraca, though comparatively scarce, were more numerous and better represented than in the two previously described; they comprised the following species:—

Diaptomus gracilis, G. O. Sars.
Cyclops serrulatus, Fischer.
Bosmina longirostris (Müller).

4. The "American Loch."

This loch is also probably situated in the vicinity of Loch Uisg. The material from it was collected on the same date as that from Loch Uisg, and consisted of a shore gathering. Three species of fresh-water Entomostraca were obtained, and are as follow:—

Diaptomus gracilis, G. O. Sars.
Cyclops strenuus, Fischer.
Bosmina longirostris (Müller).

A specimen of *Scutellidium viride*, a littoral marine species, was obtained in this material, but it had probably been accidentally introduced.

5. LOCH AIRDEGLAIS.

The Lussa Water, in an upland valley near its source, north-west of Creach Bheinn, forms a number of expansions or "lochs" that extend northward for nearly two miles in a more or less continuous and slightly curved line. The southmost and largest of these expansions is called Loch Airdeglais or Ardglash, the northmost is called Loch Squabain or Scuban, and between these are two other and smaller lochans. Loch Airdeglais was visited on the 19th of March 1890, when two collections were made,—one a shore gathering, the other a surface tow-netting. In the former the following species were obtained:—

Diaptomus gracilis, G. O. Sars.
Cyclops serrulatus, Fischer.
Bosmina longirostris (Müller).
Eurycercus lamellatus (Müller).

In the surface tow-netting only three species were obtained but individuals were more plentiful than in the shore gathering. The species were as follow:—

Diaptomus gracilis, G. O. Sars.
Bosmina longirostris (Müller).
Daphnella brachyura (Liévin).

6. THE "MIDDLE LOCH."

Though I have been unable to find any loch called th "Middle Loch" on the Ordnance Survey map of the islan of Mull, there is every probability that the name is applie to one of the two small sheets of water or expansions of th Lussa River, situated between the loch last described, viz Loch Airdeglais and Loch Squabain, for the reason that a three lakes were visited on the same day, viz., on 19t March, while at a later date—viz., 4th July—the "Middl Loch" and Loch Squabain were again visited on the sam day. The material from the Middle Loch consisted of thre collections—(1) a shore gathering, got on the 19th of March (2) a surface and an under-surface tow-net gathering, collecte on the 4th of July 1890. In the shore gathering made i March the following species were obtained:—

Diaptomus gracilis, G. O. Sars.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Bosmina longirostris (Müller).
Alona quadrangularis (Müller).
Acroperus harpæ, Baird.

The surface tow-net gathering of 4th of July contained a large number of Entomostraca, especially of Cladocera. The following are the species then obtained:—

Diaptomus gracilis, G. O. Sars.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Sida crystallina (Müller).
Daphnella brachyura (Liévin).
Ceriodaphnia reticulata (Jurine).
Bosmina longirostris (Müller).
Eurycercus lamellatus (Müller).
Chydorus globosus, Baird.
Polyphemus pediculus (Linné).
Bythotrephes longimanus, Leydig.

In the under-surface tow-net gathering, collected on the same date as the last, the following species were obtained:—

Diaptomus gracilis, G. O. Sars.
Daphnella brachyura (Liévin).
Bosmina longirostris (Müller).
Acroperus harpæ, Baird.
Polyphemus pediculus (Linné).
Bythotrephes longimanus, Leydig.

7. LOCH SQUABAIN (or SCUBAN).

Loch Squabain, as already described, is the northernmost of the group of small lochs near the source of the river Lussa, and was visited on the 19th of March, and again on the 4th of July 1890. On the former date a shore gathering was collected, and on the latter visit a surface and an under-surface gathering were got. Six species were obtained in the shore gathering, the names of which are as follow:—

Diaptomus gracilis, G. O. Sars.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Bosmina longirostris (Müller).
Acroperus harpæ, Baird.
Alona quadrangularis (Müller).

The surface tow-net gathering collected on 4th Jul was rich in Cladocera. The following species wer obtained:—

Diaptomus gracilis, G. O. Sars.
Cyclops signatus (type), Koch.
Cyclops viridis (Jurine).
Sida crystallina (Müller).
Daphnella brachyura (Liévin).
Bosmina longirostris (Müller).
Eurycercus lamellatus (Müller).
Acroperus harpæ, Baird.
Camptocercus macrourus (Müller).
Alonopsis elongata, G. O. Sars.
Alona quadrangularis (Müller).
Peracantha truncata (Müller).
Chydorus globosus, Baird.
Polyphemus pediculus (Linné).
Bythotrephes longimanus, Leydig.

The under-surface tow-net gathering was from a depth o one fathom, and was collected on the same date as th surface gathering. Twelve species were obtained in thi gathering, the names of which are as follow:—

Cypris reticulata.
Diaptomus gracilis, G. O. Sars.
Cyclops viridis (Jurine).
Cyclops serrulatus, Fischer.
Sida crystallina (Müller).
Daphnella brachyura (Liévin).
Bosmina longirostris (Müller).
Ilyocryptus sordidus (Liévin).
Alonopsis elongata, G. O. Sars.
Eurycercus lamellatus (Muller).
Chydorus globosus, Baird.
Polyphemus pediculus (Linné).

TABLE I.

A classified List of the Species recorded in the preceding Notes, with their distribution in the various Lochs described. In the Table, – *signifies absent,* r. = *rare,* f. = *few,* fr. = *frequent,* c. = *common.*

CLASSIFIED LIST OF SPECIES.	SWISS LOCH.	LOCH UISG.	SHEEP LOCH.	AMERICAN LOCH.	LOCH AIRDEGLAIS		MIDDLE LOCH.			LOCH SQUABAIN.		
	Shore Gathering.	Gathering from 4 fathoms.	Shore Gathering.	Shore Gathering.	Shore Gathering.	Surface Gathering.	Shore Gathering.	Surface Gathering.	Under-surface Gathering.	Shore Gathering.	Surface Gathering.	Gathering from 1 fathom.
OSTRACODA.												
reticulata, Zaddach, . .	–	–	–	–	–	–	–	–	–	–	–	f.
COPEPODA.												
mus gracilis, G. O. Sars, .	f.	fr.	f.	f.	f.	c.	r.	fr.	fr.	f.	fr.	c.
s signatus, Koch (type), .	–	–	–	–	–	–	–	–	–	–	f.	–
s strenuus, Fischer, . .	–	–	–	fr.	–	–	–	–	–	–	–	–
s viridis (Jurine), . .	–	–	–	–	–	–	f.	f.	–	f.	r.	f.
s serrulatus, Fischer, . .	f.	–	f.	–	f.	–	r.	f.	–	r.	–	c.
CLADOCERA.												
rystallina (Müller), . .	–	–	–	–	–	–	–	r.	–	–	r.	c.
ella brachyura (Liévin), .	–	–	–	–	–	f.	–	c.	c.	–	c.	c.
laphnia reticulata (Jurine), .	–	–	–	–	–	–	–	f.	–	–	–	–
na longirostris (Müller), .	–	–	r.	f.	f.	r.	r.	c.	c.	f.	c.	f.
yptus sordidus (Liévin), .	–	–	–	–	–	–	–	–	–	–	–	f.
ercus lamellatus (Müller), .	–	–	–	–	f.	–	–	f.	–	–	f.	c.
erus harpæ, Baird, . .	–	–	–	–	–	–	f.	–	r.	r.	r.	–
tocercus macrourus (Müller),	–	–	–	–	–	–	–	–	–	–	r.	–
psis elongata, G. O. Sars, .	–	–	–	–	–	–	–	–	–	–	f.	f.
quadrangularis (Müller), .	–	–	–	–	–	–	r.	–	–	r.	r.	–
antha truncata (Müller), .	–	–	–	–	–	–	–	–	–	–	fr.	–
rus globosus, Baird, . .	–	–	–	–	–	–	–	fr.	–	–	r.	c.
hemus pediculus (Linné), .	–	–	–	–	–	–	–	fr.	f.	–	f.	r.
trephes longimanus, Leydig,	–	–	–	–	–	–	–	f.	r.	–	r.	–

REMARKS ON THE DISTRIBUTION OF SOME OF THE RARER SPECIES RECORDED IN THESE NOTES.

OSTRACODA.

Cypris reticulata, Zaddach.

This was the only Ostracod observed in the material from the Mull lochs; its distribution in Scotland is limited to comparatively few places, and these are chiefly in the sout and west. The present record is an extension of the dis tribution of *Cypris reticulata* northward on the west side Scotland ; on the east side we have a record of its occurrenc at Loch Achnacloich, near Invergordon, Ross-shire.

COPEPODA.

The Copepoda recorded in this report, with, perhaps, on exception, belong to species that are more or less generall distributed throughout Scotland. *Cyclops strenuus* is muc less common than the others, and its occurrence in the Mu lochs is of interest, as being an extension of its distribution the West Coast.

CLADOCERA.

Sida crystallina (Müller).

This is a large and apparently a local species in Scotlan I have records of it from only two other places, viz., Greens Loch, near Rothesay, Island of Bute, and Raith Lake, ne Kirkcaldy, Fifeshire, in both of which it is moderate common.

Daphnella brachyura (Liévin).

This species is considerably smaller, and is perhaps mo generally distributed than the last, and, like it, seems prefer the shelter of aquatic plants rather than the op water.

Ceriodaphnia reticulata (Jurine).

The distribution of *Ceriodaphnia reticulata* appears to local, but the species may be a common one where it do occur. It was very common in Loch Strathbeg, Aberdee shire, in September 1890.

Camptocercus macrourus (Müller).

This also appears to be one of the less common species Scottish Cladocera. I have met with it in material fro only two other localities in Scotland, viz., Castle Loc Lochmaben ; and Loch Morar, Inverness-shire.

Chydorus globosus, Baird.

There are very few Scottish records for this fine species, and they are all from the west side; the localities to which these records refer are Paisley Canal (Robertson and T. Scott); the Hebrides (Rev. A. M. Norman); Lismore Island, Argyllshire (T. Scott).

Bythotrephes longimanus, Leydig.

This curious Crustacean, with its enormously long post-abdominal spine, would seem to be widely, if not generally, distributed in Scotland. I have obtained it in Loch Leven, Kinross-shire, and in Loch Ness and Loch Morar, Inverness-shire. Its occurrence in the Mull lochs is a further extension of its distribution on the West Coast.

XXIV. *The Penguins of Erebus and Terror Gulf.* By C. W. DONALD, M.B., C.M.

(Read 21st February 1894.)

During the late Antarctic expedition by the Dundee whalers, we met with four species of penguins in the neighbourhood of Erebus and Terror Gulf, viz.,—(1) The Emperor, *Aptenodytes Fosteri* (G. R. Gray); (2) *Pygoscelis Adeliæ* (Hombron and Jacquinot), and *Dasyrhamphus Herculis* (Finsch); (3) *Pygoscelis Antarctica* (Forst.); and (4) The Johnnie or White-headed Penguin, *Pygoscelis taeniata* (Peale).

The Emperor penguin we saw swimming on one or two occasions in lat. 63° S. Several were again seen on ice-floes to the south of 64°, and again in the north of the Erebus and Terror Gulf, directing the motions of schools of smaller penguins.

Dr Sclater, in speaking of this bird,[1] says that it has been met with on three previous occasions: by Cook in 1774-75, by Ross in 1840-43, and by the United States Exploring Expedition in 1840. Weddell and others must, of course, have seen it, but brought no specimens home, and could not distinguish it from its near ally, the King Penguin.

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[1] Ibis, July 1888.

In 1888 ten specimens only were known of as existin
museums—seven in this country, two in Germany, and
in the United States.

Sclater gives as its authenticated range Victoria, Ade
and Wilkes' Lands, and seems to express some doubt
to whether it ever inhabited South Georgia. He t
describes the specific differences between this bird and
King Penguin, *Aptenodytes Pennantii*, comparing them b
as to external characters and as to skeleton, and conclu
by saying, "If the skeletons of the two species were o
known as fossils, they might well have been referred
different genera." Several naturalists—among them Mi
Edwards—seem inclined to minimise the specific differen
between the two.

Six skins were brought home by our expedition, five
them in good plumage, the sixth, a young one, in imperf
plumage. In addition to these, one complete and one par
skeleton were obtained.

The great strength of these birds can scarcely be credit
Mr Bruce, of the "Balæna," vividly describes the captur
their largest specimen, which they took on board alive,
skin of which is now in the Edinburgh Museum of Scie
and Art. Five men attempted to hold the bird down on
ice, but were quite incapable of doing so, and got thro
about like so many nine-pins. Eventually they got
leather belts strapped round him, and standing back, too
breath. So did the penguin, and burst the belts. A st
rope was then fastened round him, his legs, flippers, and n
being all tied together. In spite of this he again got lo
in the small boat. On being taken on board, he nea
stunned the ship's dog by a blow with his flipper. The s
measures 4 ft. 10 ins. in length. The bird itself weig
74 lbs. A specimen which I had on board the "Acti
weighed 60 lbs., and measured 45 ins. in vertical height a
would have stood in the erect position. Its greatest circu
ference was 37½ ins., and the length from tip to tip of
flippers 36½ ins.

Captain Larsen, of the s.s. "Jasen," sealer, reports that
saw very large penguins in the water and on the ice in gr

numbers about lat. 64° S., and between the meridians of 47° and 49° W. The stomach of one of the large penguins which I examined contained the following heterogeneous mixture:—Several beaks of very large cuttlefish, a large number of schizopodous crustacea, some fish bones, and a considerable quantity of angular pebbles.

The *Pygoscelis Adeliæ*, or *Dasyrhamphus Adeliæ* (H. and J.), was by far the most common form. It was daily to be seen swimming or sitting on the ice in tens or twenties, or sometimes in large schools. We had ample opportunities of watching the peculiar gait and attitudes of this bird, which he shows in common with many of his tribe, and which indeed have often been described before. Standing absolutely erect, he supports himself on the tripod of feet and tail. As he waddles along, with his feet as it were tied together, and trying to balance himself by vigorous movements of his flippers, his tail cuts a deep furrow in the snow, broken at intervals as he half loses his balance and sways forwards: hurrying on, he soon loses his balance altogether, and topples forward on to his breast, in which attitude he proceeds at an even more rapid pace, the flippers being used alternately as paddles and the feet pushing behind—the tail in this position not touching the snow. In the water his modes of progression are also two. Usually he is seen to swim under water in a prolonged dive, broken at intervals of about 30 yards as he rises for breath, leaping clear out of the water to the height of perhaps a foot, and immediately disappearing with scarcely a ripple, after clearing a space of about two or two and a half feet. Swimming thus, the feet remain motionless, and only the flippers are used alternately as powerful paddles. In this way he shoots along with great rapidity. The other mode of swimming develops but a slow pace; floating on the surface like a cormorant, he swims in the ordinary way by means of his webbed feet, his wings remaining idle. On leaving the water for the ice, he shoots straight up from below the surface, and lands in an erect position, looking for all the world like a jack-in-the-box. In this way he can jump on to a piece of ice as much as two and a half feet above the water-line.

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In Mr Spry's notes on the voyage of the "Challenger," he states, as the result of an experiment, that a penguin perished on being held under water for a space of one and a half minutes.[1] To test this statement I repeated the experiment, and held a penguin below the surface for the space of six minutes. At the end of two minutes, among other violent struggles, convulsive pumping of the chest occurred, again at the end of four and a half minutes and again immediately before I released the bird. Though considerably exhausted, it recovered satisfactorily, and was set at liberty half an hour afterwards. To account for this discrepancy in the two results, I may say that I carefully excluded water from the lungs by compressing the trachea whereas in the experiment mentioned by Mr Spry the bird was simply lowered below the surface in a lobster creel.

On one occasion (January 5th), in the north of the Erebus and Terror Gulf, we had the opportunity of seeing the birds swimming in large schools of from 200 to 300, the move ments of the schools being controlled by a single individua which followed in the rear, and which appeared to be o larger size, though we could not approach close enough t determine its character. When first seen, at a distance o about 200 yards, the school nearest the ship were leaping o diving noisily. On a croak from the leader this noisy spor instantly ceased, and the whole school swam quietly alon for a short time. In response to another and slightl altered croak, the leaping and diving recommenced. O a third croak, the whole school disappeared in a prolonge dive. On the evening of the same day, we saw on a piec of ice about forty black-throated penguins grouped roun a pair of large penguins of a different species, possibl identical with those that had directed the schools. Th sailors said it reminded them of a marriage ceremony. On of the larger penguins was preserved, and proves to be a Emperor in young plumage. Among the black-throate penguins was one individual a little smaller than the rest with the back and tail of a brown colour, and the bill als brown, and apparently shorter and deeper than the others

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[1] The Cruise of H.M.S. "Challenger," by W. J. I. Spry, R.N., p. 96.

This specimen was unfortunately lost. On the same piece of ice were a *Chionis* and a seal. It was found over and over again, from inspection of the seals' stomachs, that the penguins form the main part of their diet; but at the same time the penguins, while on the ice, show no fear of the seals, and it is therefore probable that they are captured while in the water or during the night. The seals leave the ice about seven in the evening to feed, returning about nine o'clock in the morning to bask during the day.

We saw these black-throated penguins as far south as we went, that is about 64½°, and I have no doubt they extended much farther. Within 30 miles of the land they were fairly numerous, but at a greater distance from shore, even in the midst of abundant ice of the same character, they became scarce, and only very few were seen 90 miles from land.

Four penguin rookeries were seen about the south of Joinville Island. One of these—a very large one—belonging to this species was visited. It is situated on the north shore of what our captain has called "the Firth of Tay." I had not the good fortune to land upon this rookery; according to the boat's crew who did so, the birds were in countless multitudes. The nests were crowded together in blocks formed by pathways running nearly at right angles to one another, and the birds were uniformly of the same species. Two eggs from this rookery measure 2·5 inches by 2 inches, and 2·6 by 2·1 inches.

The cry is seldom heard, and mostly at night or when the birds are disturbed. It is a short, rather harsh "quangk;" among themselves, when undisturbed, they make a gentle crooning sound. Their food consists mainly of a rather large red shrimp-like crustacean of the genus *Euphansia.* Their stomach frequently contained a number of pebbles.

About the second week in February we began to see, between the latitudes of 62½° and 63½°, large flocks of a white-throated penguin, described as *Dasyrhamphus Herculis* by Dr O. Finsch,[1] and at the same time the black-throated form became much scarcer, not more than half a dozen to a dozen being seen during the day. It certainly seemed

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[1] Proc. Zool. Soc., 1870, p. 332, pl. xxv.

to me that these white-throated birds were but
young of the black-throated variety, though they mus
this case have been only about six weeks old. The
throat—the only point of distinction in the pluma
showed in many cases a grey tint, small black feathers s
ing through among the white. In a skin brought home
lower part of the breast is still downy—the long down
not yet covered by the contour feathers. The bi
somewhat lower than in the black-throated birds. Fur
it may be noted that the tenderness of the w
throated birds was remarked by all. No rookeries of
species were seen. In short, though the presence, so e
in the season, of large flocks of young birds unmixed
older ones, is sufficiently remarkable, yet the weigh
evidence seems to be in favour of this interpretation,
against the existence of *Dasyrhamphus Herculis* as an
dependent species. This agrees with the observation
Mr Gray, Dr Coues, and Count Salvadori.

Of the *Pygoscelis Antarctica* (Forst.), or Ringed Peng
I only saw a single specimen, which I obtained to the s
of lat. 64° S., and about 15 miles to the east of Seym
Island; but several others were seen by Mr Bruce of
"Balæna," on their first making the ice, in the vicinity of
South Shetlands. A sailor on board the "Active" descr
another ringed variety seen off Seymore Island. In addi
to the black ring round the throat, it had a white patch
the crown of the head, and the bill and feet of an ora
colour—thus apparently combining the characters of
species with those of the *Pygoscelis taeniata*. I am incli
to doubt whether *Pygoscelis Antarctica* should be allo
specific rank, and would rather favour its being regarded
a variety of *Pygoscelis Adeliæ*.

The *Pygoscelis taeniata* (Peale) was seen in the water
several occasions, and was easily recognised by its w
crown and loud "quangk," much harsher and more pe
trating than that of any of the other forms met with.
January 6th I landed on a small rookery belonging to
species, situated at the western extremity of Dundee Isl
—so called by our captain. It was placed about a sto

throw from high-water mark, on the top of a horseshoe-shaped hillock, and consisted of some forty nests. No paths were seen to approach it from the sea, nor could a path well have been beaten down in the hard stoney clay which formed the hillock. Each nest was composed of small stones or clayey earth heaped together into the shape of a small conical mound, with a depression some 3 inches deep in the centre. This latter was lined with feathers and down from the parents, most of which showed upon the lower part of their breasts a strip of bare red skin from which the feathers had been pulled. Rather more than half the eggs were already hatched; and in many of the nests one of the two eggs was already hatched, while it was still possible to blow the other. I did not notice a difference in the size of the two eggs, such as is described by Mr Sharp in his paper on Kerguelen Land.[1] Two eggs brought home are of a chalky white colour with a faint tinge of blue, and measure 2·7 inches by 2·2 inches, being thus distinctly larger than those of the *Pygoscelis Adeliæ.*

No crested penguins of any species were seen by any of the Dundee ships south of the Falklands. But Captain Larsen of the Norwegian sealer "Jasen" saw, on the South Orkneys, a rookery of birds, which he describes as being intermediate in size between the Emperor and the *Pygoscelis Adeliæ,* having a yellow patch under each eye and a red supraciliary crest extending backwards on each side of the head to a length of 3 to 4 inches. Captain Larsen is an acute and careful observer, and took great interest in the natural history of the voyage. He had preserved two specimens of this penguin, but both had disappeared—having been removed by the crew. Captain Larsen repeated his description to me on two occasions in identical terms. This description does not tally with that of any other species, and no crested form has, as yet, been described as inhabiting the South Orkneys. I am left with the impression that an entirely new species is probably indicated.

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[1] Phil. Trans., clxviii.

XXV. *Results of Meteorological Observations taken at Edinburgh during* 1893. By R. C. MOSSMAN, Esq., F.R.S.E., F.R.Met.Soc. [Plate X.]

(Read 21st February 1894.)

During the past year no change has been made in the methods of observation or in the equipment of the station. A "Fortin" standard barometer has been added to the stock of instruments,[1] but the values given in the tables have been obtained from readings of the Kew marine barometer described in last year's report. New averages for the last 130 years are in process of computation, but beyond the means for temperature none are as yet completed. In order to show the more intimate relation existing between the various elements of climate, weekly averages of pressure, temperature, rain, and sunshine have been calculated, the number of days on which east and west winds respectively prevailed being also given, north winds being referred to the former, and south winds to the latter direction. A table of weekly mean temperature variability has also been added. These values are obtained by taking the mean temperature $\left(\frac{\text{max.} + \text{min.}}{2} = \text{mean temp.}\right)$ difference from day to day. For example, the mean temperature of December 15th was 46°·4, and for the day following 51°·6; the variability was thus 5°·2. It may be remarked that this variability is quite distinct from daily range, which is greatest in spring and summer, whereas the greatest changes in the mean temperature of successive days take place in winter, when the absolute quantity of aqueous vapour is at a minimum.

The thickness of the rainband in the spectrum of sunlight has been observed three times daily throughout the year, viz., at 9 A.M., noon, and 3 P.M., an extra observation being taken at 6 P.M. when there is sufficient light. The scale employed ranges from 0 to 6, the rainband being compared with the three lines B, *b*, and F, to which values corresponding to 1, 2, and 3 respectively have been given.

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[1] The following are the instruments in use :—

Pressure.—Standard "Fortin" barometer, Kew marine do., mercurial barograph, Richard barograph.

Temperature.—Max. and min. thermometers, black bulb solar radiation thermometer, bright bulb terrestrial radiation thermometer, Richard thermograph.

Humidity.—Mason's hygrometer, Richard hygrograph.

Miscellaneous.—Robinson anemometer, wind vane, sunshine recorder, rain gauge, storm rain gauge, rainband spectroscope, koniscope and stephanome.

REMARKS ON THE METEOROLOGY OF 1893.

January.—The month opened with low temperatures, high pressure, and but little sunshine, less than one hour being recorded in the first week, during which time easterly winds prevailed, accompanied by frequent snow showers. A shade minimum of 15° was registered on the 6th, the exposed thermometer falling to 7° on the same date. On the 16th a spell of mild, unsettled weather set in, which continued till the end of the month, the wind occasionally rising to the force of a gale. Although rain fell on 22 days, the aggregate was no less than 71 per cent. below the normal.

February.—Throughout the month mild, showery, and generally unsettled weather was experienced. The winds during the first three weeks were nearly all from a westerly quarter, with the result that a considerable amount of bright sunshine was recorded; but during the last week an easterly air current prevailed, sunshine being deficient. A gale from the S.W. occurred on the 14th, but with this single exception light airs prevailed. Barometric pressure was low, except from the 3rd to the 6th, when readings exceeding 30 inches[1] were recorded. Snow showers fell during the last week.

March.—The month opened with a low barometer and a sharp snowstorm from the east, yielding 0·37 inch of water. On the 2nd, however, a rapid recovery of pressure set in, which proved the precursor of a spell of exceptionally fine, dry, warm conditions, broken only by a rainfall of 0·17 inch on the 15th. Radiation was very large during the week ending the 25th, when the mean daily range of temperature amounted to no less than 24°·1, being twice the average. A large proportion of sunshine was recorded. The winds were chiefly from the west, and strong in force from the 3rd to the 17th. The mean temperature was the highest since 1882.

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[1] All barometer readings have been corrected to 32° and reduced to sea-level.

April.—Unusually fine weather was experienced during the greater part of the month, the first 12 days being rainless. On the 15th a wet period extending over a week set in, an inch and a half of rain falling. In spite of the fact that pressure remained high and steady, no sunshine was recorded from the 16th to 18th. During the last ten days only 0·15 inch of rain fell, while sunshine was abundant although easterly winds prevailed. Temperature was again much above the average, the month being the warmest April for 23 years. Barometric pressure was higher than in any April for at least 40 years, values not being at present available for comparison prior to 1853.

May.—During the greater part of the month both pressure and temperature were high, but sunshine was comparatively small in amount, being 26 hours less than in April, in spite of the longer days. The rainfall was small, more than two-thirds of the total being recorded on the 17th, 20th, and 28th. The winds were light, and about equally divided between east and west, the cloudy conditions accompanying the easterly winds off the North Sea being responsible for the comparative deficiency of sunshine. Temperature was much in excess of the average, being the highest since 1848. Thunderstorms occurred on the 19th, 20th, and 21st; while lightning, without thunder, was seen on the 28th.

June.—The first three weeks of June were very fine, rain being virtually absent, less than $\frac{1}{8}$ of an inch being recorded during this period. Temperature was very high from the 16th to the 19th, the average maximum readings for these days being 80°·5; while on the 18th the temperature rose to 85°·9, or within 2° of the highest ever registered in Edinburgh. On the 22nd and 23rd heavy rain fell, with a N.N.E. wind, the fall for the 48 hours amounting to 1·9 inch. During the last week pressure was low, little sunshine being recorded. The average hourly air movement for the month was only 2·6 miles, the wind never rising above a moderate breeze. This was the fourth month in succession with a temperature markedly in excess of the normal, such a warm June not having occurred since 1858.

July.—Both pressure and temperature were below the normal, although rainfall showed a deficiency from the mean. There was very little sunshine during the first 15 days, only 32 hours being recorded out of a possible 258 hours. Easterly winds blew till the 16th, when a westerly air current set in, the rest of the month being sunny and comparatively dry. Thunderstorms were observed on the 2nd, 8th to 11th, 16th, 17th, and 19th, the most severe being that of the 8th.

August.—Pressure and rainfall were both about the average, although temperature was exceptionally high, especially from the 7th to the 20th, the mean for these fourteen days being 66°·2, or 8°·4 above the normal. During the fortnight under review the day maxima were all above 70°, while on the 15th a maximum of 84° was recorded. Not since August 1868 has such a warm day been experienced in this month. The nearest approach to the above prolonged spell of warmth during 40 years was a mean of 65°·2 for the fortnight ending August 8th, 1868. Sunshine was again very prevalent, the only sunless day being the 31st. Light westerly winds prevailed till the 21st, when a strong gale blew for about 10 hours. Thunderstorms were observed on the 4th and 20th. This was the warmest August experienced since 1819.

September.—Pressure and temperature during September did not depart much from the mean, but rainfall was over an inch below the average. Sunshine, especially during the second half of the month, was deficient, only 16 per cent. of the possible being registered in the week ending the 23rd. Less than half an inch of rain fell during the first three weeks, but the last week was wet, the downfall exceeding an inch. A very fine meteor was seen on the evening of the 5th.

October.—Westerly winds blew persistently throughout, east winds being observed on only two days. The first week was very fine, although the barometer was low. A heavy downpour of rain took place on the night of the 7th and 8th, nearly an inch falling in 10 hours. Remarkably mild weather prevailed from the 15th to the 21st, the mean temperature of this period being 54°·6, or nearly the average for June. Since 1864 only one milder week has occurred in October, viz., that ending the 12th October 1878, when the mean temperature was 56°. The wind rose to the force of a gale on the 24th, and was succeeded on the following day by a heavy rainfall.

November.—Pressure was low at the beginning of the month, but an anti-cyclone advanced on the 6th, readings exceeding 30·5 inches being registered from the 8th to the 12th. Very sunless weather prevailed from the 7th to the 20th, only 5 hours' sunshine being recorded. Light airs prevailed till the 16th, when a sharp northerly gale blew, accompanied by the lowest barometric reading of the year, pressure falling to 28·51 inches. In the 24 hours ending 9 A.M. of the 17th pressure fell 1·24 inch, a rise of 0·97 inch taking place in the 12 hours ending 9 A.M. of the 18th. The second half of the month was stormy, with occasional snow showers, interspersed with brief outbursts of spring-like warmth. These rapid alternations of heat and cold exerted a prejudicial influence on the health of the community, as evinced by a marked rise in the death-rate taking place concurrently with the above protean conditions.

December.—The month opened with cold weather, the maximum on the 1st being 33°·5. After the 3rd very mild weather prevailed, with one slight interruption, till the end of the year. Storms were frequent, that of the 8th being the most severe—the anemometer recording a mean velocity of 43·5 miles per hour for the 10 hours ending 6 P.M. Sunshine was about the average, there being no spell either of sunny or sunless conditions. Rain or snow fell every day from the 4th to the 14th. A well-marked anti-cyclonic period set in on the 26th, the barometer rising on the 29th to 30·64 inches. This was the mildest December since 1865.

ON THE WARM SPRING AND SUMMER OF 1893.

A few remarks summarising the more salient features of the unprecedented warmth of the spring and summer may not be out of place. We have, for the purpose of comparison, tables of mean monthly temperatures taken at Edinburgh since 1764 to the present time, 130 years in all.

Much labour has been expended in computing and verifying the earlier observations, and in making them comparable with each other, by reducing them all to the mean of maximum and minimum thermometers, and to a height of 250 feet above sea-level. In this connection my best thanks are due to Dr Buchan, who kindly placed at my disposal all the old manuscript observations in possession of the Scottish Meteorological Society. I do not propose, at the present time, to give a description of these old observations, where they were made, and by whom, as I hope to bring the results of an investigation on the meteorology of Edinburgh during these 130 years before another society at an early date. It will be sufficient to say that no effort has been spared to detect and eliminate any sources of error. The principal results of the investigation are summarised in the following table:—

Month.	Above average.	Warmest since	Above average.	No. of warmer back to 1764.
1893.	°		°	
March, . .	3·7	1882	4·2	11
April, . . .	3·1	1870	4·1	11
May, . . .	4·0	1848	5·5	5
June, . . .	2·9	1858	3·3	10
August, . .	3·8	1819	4·9	3
December, . .	3·9	1865	5·1	11

Taking the mean temperature of the spring months, March, April, and May, we find that it exceeded the average by 3°·6, being absolutely the warmest during the past 130 years. The nearest approach to this remarkable spell of vernal warmth was in 1779, when the mean for these three months was 3°·2 above the average. The spring drought in Edinburgh was far from being remarkable, a fall of 3·89 inches of rain being spread over 27 days, while in 1883 the rainfall for these three months was 3·83 inches, and in 1875 2·05 inches. The longest period without rain was from April 1st to 12th, whereas in some parts of the south of England no rain fell for over seven weeks. The mean barometric pressure for March, April, and May was 30·086 inches, being the highest for these months so far as this element of climate has been discussed, viz., 1854. Values are available since 1764, but they have not yet been reduced.

In spite of a July with a mean temperature 0°·9 below the average, the summer was the hottest since 1868, while, taking the mean temperature of the six months ending August, we find that it was the highest for the above-extended period since 1826 ("the year of the short crop"). The average excess of temperature for these six months was 2°·8 in 1893, 3° in 1826, and 4°·1 in 1779.

The mean temperature of the year comes out 2° above the 130 years' average, the only warmer years being 1857, 2°·6 above the normal, and 1846 and 1779, when the excess amounted to 2°·7.

NOTEWORTHY PHENOMENA IN THE METEOROLOGY OF 1893.

Highest barometric reading 30·653 inches, on April 8th, at 8 A.M.

Lowest barometric reading 28·510 inches, on November 17th, at 11 A.M.

Highest temperature in shade 85°·9, on June 18th, at 3 P.M.

Lowest temperature in shade 15°·0, on January 6th, at 2 A.M.

Greatest range of temperature 28°·5, on June 18th.

Least range of temperature 3°·2, on January 2nd.

Highest temperature in sun's rays (black bulb thermometer in *vacuo*) 136°·3, on June 18th.

Greatest excess of sun maximum over shade maximum, 60°·0, on May 30th.

Lowest temperature on grass 7°·5, on January 6th.

Greatest difference between minimum on grass and in shade, −12°·2, on March 25th.

Sunniest day June 18th, with 15 hours 9 minutes bright sunshine, being 87 per cent. of the total possible.

Stormiest day December 8th, average velocity of wind 30 miles per hour.

Greatest daily rainfall 1·00 inch, on June 22nd.

	Barometer at 32° and Sea-Level.					Temperature in Shade 4 Feet above Grass.									
	Mean.	Diff from Average, 1854-93.	Highest.	Lowest.	Monthly Range.	Mean.	Diff. from Average, 1764-1893	Highest.	Lowest.	Monthly Range.	Mean of Maxim	Mean of Minim.	Mean Daily Range.	Greatest Daily Range.	Mean Daily Variability.
	Inches.	Inches.	Inches.	Inches	Inches.	°	°	°	°	°	°	°	°	°	°
January, .	30·007	+ ·209	30·496	29·244	1·252	37·6	+0·9	52·4	15·0	37·4	41·5	33·6	7·9	16·1	2·9
February, .	29·540	− ·341	30·295	28·668	1·626	39·8	+1·4	54·9	25·1	29·8	44·8	34·9	9·9	17·5	2·9
March, .	30·008	+ ·154	30·447	29·272	1·175	43·9	+3·7	67·0	24·9	42·1	51·3	36·5	14·8	28 0	2·4
April, . .	30·192	+ ·276	30·653	29·691	0·962	47·9	+3·1	69·5	34·0	35·5	56·1	39·8	16·3	24·6	3·1
May, . .	30·058	+ ·116	30·592	29·470	1·122	54·0	+4 0	70·5	36·9	33·6	61·5	46·5	15·0	23·4	2·3
June, . .	29·988	+ ·042	30·434	29·244	1·190	58·6	+2·9	85·9	43·6	42·3	66·8	50·5	16 3	28·5	3·2
July, . .	29·860	− ·027	30 221	29·254	0·967	57·8	− 0·9	72·5	44·2	28·3	64·4	51·1	13 3	25·3	2·2
August, .	29·928	+ ·062	30·331	29·147	1·184	61·6	+3·8	84·0	42·6	41·4	69·6	53·7	15·9	25·6	2·1
September,	29·739	− ·133	30 330	28·796	1·534	53·6	0·0	72·7	34·9	37 8	60·6	46·7	13·9	23·5	3·1
October, .	29 730	− ·092	30 376	28·992	1·384	49·0	+1·8	65·2	29·0	36·2	55·4	42·5	12·9	18·9	3·3
November,	29·986	+ ·116	30·553	28 510	2·048	40·6	− 0·5	55·1	28 4	26·7	45·3	36·0	9·3	19·8	3 4
December,	29·739	− ·074	30·643	28·569	2·074	42·0	+3·9	53·9	25·0	28·9	46·3	37·8	8·5	16·0	3·5
Year, . .	29·898	+ ·028	30·653	28·510	2·143	48·9	+2·0	85·9	15 0	70·9	55·3	42·5	12·8	28·5	2·9

	Rainfall.				Cloud 0–10.			Solar Radiation. Black Bulb in *Vacuo.*			
	Total.	Diff from Average 1865-92.	No. of days ·01 in. or more fell.	Maxim. Fall in 24 hours.	9 A.M.	9 P.M.	Mean.	Maxim. in Sun.	Mean.	Average excess over Shade Maxim.	Greatest excess over Shade Maxim.
	Inches.	Inches.		Inches.				°	°	°	°
January, . . .	0·71	−1·72	22	0·11	8·6	6·1	7·4	84·3	53·0	11·5	33·2
February, . .	2·63	+0·67	20	0·68	6·7	6·0	6·4	91·7	70·6	25·8	51·4
March, . . .	0·88	−1·09	8	0·37	6·1	3·3	4·7	104·0	86·1	42·2	47·5
April, . . .	1·64	−0·42	9	0·58	6·9	5·8	6·4	118·2	96·9	40·8	56·8
May, . . .	1·37	−0·72	10	0·51	8·1	8·0	8·0	126·7	108·9	47·4	60·0
June, . . .	2·48	+0·38	11	1·00	7·0	5·5	6·2	136·3	111·7	44·9	58·2
July, . . .	2·53	−0·83	19	0·47	8·6	8·1	8·4	124·2	107·0	42·6	59·7
August, . . .	3·16	−0·32	17	0·52	7·4	5·6	6·5	134·0	117·0	47·4	55·6
September, . .	1·67	−1·25	17	0·47	7·0	3·7	5·4	120·5	99·7	39·1	59·4
October, . . .	2·51	+0·11	14	0·80	5·4	3·3	4·4	111·5	89·2	33·8	51·5
November, . .	1·74	−0·90	14	0·89	6·8	5·8	6·3	76·7	58·4	13·1	39·6
December, . .	2·50	+0·02	18	0·48	6·3	4·3	5·3	69·5	54·5	8·2	20·8
Year, . . .	23·82	−6·07	179	1·00	7·1	5·5	6·3	136·3	87·7	32·2	60·0

	Terrestrial Radiation.				Horizontal Air Movement.			
	Minim. on Grass.	Mean.	Average Diff. from Shade Minim.	Greatest Diff. from Shade Minim.	Total.	Mean Hourly Velocity.	Maxim. in 24 hours.	Mean Wind Force, 0-12.
	°	°	°	°	Miles.	Miles.	Miles.	
January,	7·5	28·8	-4·8	-7·9	3,875	5·2	408	1·00
February,	21·4	30·5	-4·4	-7·8	3,986	5·9	428	1·28
March,	20·1	30·5	-6·0	-12·2	5,702	7·7	460	1·14
April,	28·1	35·3	-4·2	-10·0	2,926	4·0	260	0·78
May,	31·5	42·4	-4·1	-8·7	3,289	4·4	415	0·75
June,	37·2	46·4	-4·1	-7·1	1,857	2·6	216	0·62
July,	40·3	48·4	-2·7	-5·8	2,746	3·7	311	0·55
August,	35·7	49·4	-4·3	-7·0	2,841	3·9	479	0·76
September,	30·2	41·5	-5·2	-8·8	4,481	6·2	315	1·02
October,	23·9	37·6	-4·9	-8·3	5,362	7·2	415	1·02
November,	24·9	31·7	-4·3	-7·8	4,344	6·0	485	0·90
December,	20·0	32·9	-4·9	-9·6	7,318	9·8	712	1·22
Year,	7·5	38·0	-4·5	-12·2	48,707	5·5	712	0·92

	Humidity. Saturation = 100.					Tension of Vapour.			Weight of Vapour in Cubic foot of Air.	Rainband 0–6.		
	9 A.M.	9 P.M.	Mean.	Max.	Min.	9 A.M.	9 P.M.	Mean.		Mean.	Max.	Min.
	°/₀	°/₀	°/₀	°/₀	°/₀	Inch.	Inch.	Inch.	Grains.			
January, . .	83·2	81·2	82·2	96	59	·193	·187	·190	2·17	1·18	2·0	0·5
February, . .	82·1	81·2	81·6	100	47	·204	·196	·200	2·31	1·30	3·5	0·0
March, . . .	77·6	81·7	79·6	100	37	·227	·222	·224	2·55	1·40	2·5	0·5
April, . . .	76·8	84·5	80·6	97	46	·254	·250	·252	2·90	1·23	2·0	0·5
May, ...	75·5	83·5	79·5	95	58	·324	·303	·313	3·52	1·18	2·5	0·5
June, ...	70·6	80·1	75·4	98	37	·361	·358	·360	3·25	1·18	2·5	0·5
July, ...	78·2	83·8	81·0	97	45	·375	·371	·373	4·14	1·12	3·5	0·5
August, . . .	77·4	82·0	79·7	95	42	·425	·409	·417	4·57	1·12	2·5	0·5
September, . .	77·8	81·1	79·4	96	45	·325	·312	·418	3·55	1·02	4·0	0·5
October, . . .	81·0	82·9	81·9	97	49	·278	·272	·275	3·12	0·98	1·5	0·5
November, . .	80·6	81·8	81·2	99	42	·206	·213	·210	2·37	1·14	3·0	0·5
December, . .	83·0	82·5	82·8	97	45	·225	·223	·224	2·59	1·13	2·5	0·5
Year, ...	78·6	82·2	80·4	100	37	·283	·276	·280	3·09	1·16	4·0	0·0

Hourly Values of Bright Sunshine for Hour ending Greenwich Time.

	A.M.								P.M.								Total.	Per Cent. of possible Duration.	Greatest in One Day.	Greatest Percentage of possible in One Day.	Days with None.
	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8					
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	°/.	Hrs.	°/.	
January, .	...	...	...	...	...	0·28	4·85	5·69	7·63	6·47	4·41	0·70	...	...	...	...	30·0	13	4·0	50	12
February, .	...	...	...	0·17	1·53	6·44	10·65	10·56	8·74	8·85	10·50	4·83	1·04	...	...	...	63·3	24	7·5	71	4
March, .	...	...	0·03	4·03	8·36	11·63	16·47	16·98	20 02	18·36	14·23	16·00	10·52	0·08	...	...	136·7	37	8·7	77	6
April, . .	...	1·00	1·88	6·67	9·93	13·25	13·75	17·22	19·55	19·58	18·61	16·07	13·80	10·10	3·05	0·08	164·7	39	12·0	81	5
May, . .	0·23	4·97	6·07	6·22	7·17	9·93	10·74	12·50	12·10	12·83	11·34	11·28	10·88	10·60	8·91	2·45	138·3	27	13·5	86	3
June, . .	3·58	8·15	9·53	10·27	11·85	13·70	13·47	12·85	13·98	13·32	14·70	14·74	14·85	13·86	11·93	3·83	184·5	35	15·2	87	5
July, . .	1·50	6·08	7·33	8·83	7·80	8·52	8·53	11·25	10 39	9·25	10·19	6·72	5·74	6·44	4·90	0·76	114·2	21	11·1	67	5
August, .	0·23	2·05	6·90	9·90	13·22	15·52	17·78	17·58	14·86	17·45	17·34	17·43	12·78	9·97	4·78	0·23	178·0	38	10·9	74	1
September,	...	...	1·39	6·22	10·22	10·67	11·88	10·52	11·19	11·30	13·78	11·10	10·30	5·27	...	...	113·8	29	9·8	75	1
October, .	...	...	...	1·17	9·94	16·78	17·27	17·50	15·45	14·41	12·45	10·88	4·47	...	...	...	120·3	37	8 6	80	2
November,	...	...	...	...	...	1·96	6·00	7·08	7·83	4·45	7·25	1·41	...	...	...	...	36·0	15	4·8	53	14
December,	...	...	...	...	...	...	4·17	8·15	9·02	7·83	5·14	0·22	...	...	...	...	34·5	15	5·0	73	16
Year, . .	5·54	22·25	33·13	53·48	80·02	108·68	135·56	147·90	150·76	144·10	139·94	111·38	84·38	56·30	33·57	7·35	1314·3	29	15·2	87	74
	586·56 hrs.								727·79 hrs.												

	Wind from Observations made at 9 A.M. and 9 P.M. Number of Days it blew from certain directions.									Number of Times the following Phenomena were observed.													
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.	Solar Halos.	Lunar Halos	Rainbows.	Thunder-storms.	Lightning.	Aurora.	Snow.	Hail.	Frost in Shade.	Frost on Grass.	Mist.	Mist on Arthur's Seat.	Gales.
January,	2	1	6	1	1	1	14	2	3	3	3	2	0	0	0	5	2	11	21	0	1	1
February,	1	1	3	2	3	1	12	2	3	0	1	0	0	0	0	4	1	7	17	0	1	2
March,	1	0	3	1	0	4	16	1	5	3	2	0	0	0	0	1	0	6	20	1	2	3
April,	1	5	9	0	2	0	8	1	4	0	1	0	0	0	0	1	1	0	6	2	9	0
May,	2	0	10	2	3	1	10	1	2	1	2	0	3	1	0	0	0	0	1	0	8	1
June,	3	2	7	2	2	2	8	2	2	1	0	0	0	0	0	0	0	0	0	2	7	0
July,	1	5	7	1	1	1	10	1	4	2	0	2	8	1	0	0	0	0	0	2	7	0
August,	1	0	3	2	1	1	14	3	6	3	1	1	2	1	0	0	0	0	0	0	2	1
September,	3	1	1	1	0	5	14	3	2	2	3	0	0	0	0	0	1	0	3	0	1	0
October,	1	0	2	0	0	2	23	0	3	3	4	0	0	1	0	0	0	2	8	0	1	0
November,	5	3	4	0	1	2	9	4	2	2	1	0	0	0	1	3	0	7	18	0	2	2
December,	0	1	1	1	2	11	11	2	2	0	0	0	0	0	0	3	1	5	12	0	1	2
Year,	21	19	56	13	16	31	149	22	38	20	18	5	13	4	1	17	6	38	106	7	42	12

WEEKLY VALUES FOR 1893.

Week ending	Mean Barom. Pressure.	Temperature.					Rain.	Sunshine.		Wind: Days of		
		Max.	Min.	Mean.	Mean Daily Range.	Mean Variability		Hrs.	°/. of possible	E.	W.	Calm
	Inches.	°	°	°	°	°	Inch.					
uary 7,	30·214	35·4	15·0	28·7	7·8	3·3	0·26	0·9	2	5½	½	1
,, 14,	30·120	43·1	28·5	35·0	6·9	2·4	0·07	6·7	13	3½	2½	1
,, 21,	30·104	49·3	31·0	39·8	8·3	2·9	0·20	7·0	13	0	6½	½
,, 28,	29·803	49·9	35·7	43·4	7·6	2·9	0·03	7·3	13	½	6	½
bruary 4,	29·789	52·4	36·7	44·2	9·2	2·6	0·21	15·3	26	0	5½	1½
,, 11,	29·639	50·9	34·9	42·2	10·0	2·7	0·72	19·2	31	0	6½	½
,, 18,	29·497	54·9	28·1	40·2	11·6	3·4	0·82	16·0	24	2½	4	½
,, 25,	29·382	52·6	26·4	38·2	8·8	2·8	0·30	11·4	16	3½	2½	1
rch 4,	29·579	49·5	25·1	37·2	9·7	3·3	1·21	13·2	18	4	2	1
, 11,	30·097	55·9	37·0	46·5	11·3	2·1	0·08	23·3	30	0	7	0
, 18,	29·657	51·2	26·3	39·8	11·3	1·8	0·22	32·5	40	½	5½	1
, 25,	30·327	67·0	24·9	46·9	24·1	3·2	0·00	44·2	52	0	4½	2½
ril 1,	30·063	56·9	30·9	44·7	13·2	4·1	0·10	33·2	37	3½	3½	0
, 8,	30·339	61·2	36·5	47·5	16·7	2·6	0·00	46·5	50	3½	2½	1
, 15,	30·336	57·9	34·7	45·7	15·7	1·6	0·60	32·6	34	3½	2½	1
, 22,	30·117	69·5	34·0	48·0	14·6	6·5	0·89	24·9	25	4	2	1
, 29,	30·038	66·1	39·5	50·9	19·2	2·8	0·15	48·8	47	4	2½	½
y 6,	30·138	65·9	36·9	50·1	15·2	2·6	0·17	29·6	28	3½	2½	1
13,	30·354	70·2	41·1	54·3	15·5	2·5	0·02	51·4	47	2½	4½	0
20,	29·728	70·5	44·9	54·3	12·7	2·5	0·80	14·4	13	5	1½	½
27,	29·922	68·9	46·3	56·6	15·9	1·5	0·01	40·5	35	½	6½	0
ne 3,	30·048	69·2	42·2	54·5	17·0	3·0	0·31	32·1	27	2½	3	1½
, 10,	30·340	68·1	48·2	56·7	14·1	2·5	0·13	25·7	21	4	2½	½
, 17,	30·148	78·2	47·9	61·7	18·7	2·8	0·04	74·5	62	5	2	0
, 24,	29·760	85·9	46·6	58·7	15·1	5·3	1·89	28·2	28	4	3	0
ly 1,	29·760	70·9	45·1	58·7	15·3	2·0	0·42	42·1	35	1½	5	½
, 8,	30·038	72·5	49·0	58·3	12·3	3·8	0·77	19·6	16	5½	0	1½
, 15,	29·780	67·0	49·0	56·9	9·1	1·9	0·53	8·7	7	5½	1	½
, 22,	29·660	69·1	48·2	58·1	15·2	1·4	0·46	46·2	40	0	7	0
, 29,	29·907	69·7	44·2	57·8	15·7	2·4	0·34	30·0	27	1½	4½	1
gust 5,	29·762	66·9	49·0	57·7	12·4	1·4	1·39	25·1	23	1½	3	2½
,, 12,	30·018	81·7	45·0	63·5	17·3	2·7	0·53	26·4	25	2½	2½	2
,, 19,	29·964	84·0	53·3	67·5	18·1	2·5	0·50	54·8	53	½	5	1½
,, 26,	29·767	70·3	50·2	59·4	13·6	1·1	0·87	47·8	47	0	6½	½
ptember 2,	30·162	72·2	42·6	58·4	16·5	3·2	0·38	35·1	36	2½	4½	0
,, 9,	29·860	72·7	42·0	58·4	16·0	3·2	0·23	34·7	37	1	5½	½
,, 16,	30·053	66·3	38·8	55·4	16·0	2·8	0·00	37·1	42	½	6	½
,, 23,	29·447	61·9	34·9	49·4	12·3	4·0	0·37	13·4	16	1½	5	½
,, 30,	29·512	63·9	38·5	49·6	11·7	3·3	0·99	23·9	29	1½	5	½
tober 7,	29·312	60·2	36·3	49·6	14·9	2·5	0·83	39·1	50	½	4½	2
,, 14,	29·741	59·0	37·8	48·3	12·5	2·6	0·63	25·4	34	1½	5½	0
,, 21,	29·983	65·2	41·1	54·7	11·9	3·3	0·02	20·1	29	0	6½	½
,, 28,	29·829	57·3	36·7	47·4	12·7	4·2	0·97	18·8	29	0	7	0
ovember 4,	29·781	47·1	29·0	40·0	10·4	3·6	1·13	29·1	46	½	5	1½
,, 11,	30·381	45·3	32·3	39·6	7·6	0·8	0·22	7·5	13	4	2	1
,, 18,	29·764	52·9	29·3	40·2	9·1	3·9	0·14	2·9	5	3½	2½	1
,, 25,	30·066	50·9	28·4	38·6	9·2	3·7	0·28	10·0	19	3	4	0
cember 2,	29·952	55·0	21·5	40·6	12·8	6·9	0·03	10·9	21	1	6	0
,, 9,	29·603	51·7	33·2	43·2	8·5	4·9	0·93	2·4	5	½	6½	0
,, 16,	29·466	53·9	29·7	40·3	9·1	2·8	0·76	8·5	18	½	5½	1
,, 23,	29·415	51·6	33·5	42·2	9·6	2·8	0·14	8·1	17	½	6	½
,, 30,	30·238	49·8	37·4	45·1	6·6	2·1	0·61	4·2	9	½	5½	1

XXVI. *Animal Life observed during a Voyage to Antarctic Seas.* By W. S. Bruce, Naturalist to the s.s. "Balæna."

(Read 17th January 1894.)

The following is simply a brief abstract of the journal I kept during a voyage to the Antarctic regions last year. It does not in any way profess to contain anything of a very original nature, and is not a description of the genera and species of the animals met with and obtained during the voyage, the greater number of which will be described by Professor D'Arcy Thompson at a later date. I am especially indebted to Mr W. G. Burn Murdoch, who has given me the free use of his valuable notes and sketches.

The seals and cetaceans were our sole mammalian representatives. I shall first deal with the seals, which have been of such special interest of late.

We met with only four species of seals, all of them being true seals, and belonging to the genus *Stenorhynchus* (Allen). The Sea Elephant seal was not seen, nor were any of the Otariidæ. The four were—the Sea Leopard (*Stenorhynchus leptonyx*), Weddell's False Sea Leopard (*Stenorhynchus Weddellii*), a creamy white seal with a darker dorsal stripe, the so-called Crab-Eating Seal or White Antarctic Seal (*Stenorhynchus carcinophaga*), and Ross's Large-Eyed Seal (*Stenorhynchus Rossii*). Besides these there was another, which I think was certainly a younger form of the Sea Leopard, the apparent greater sleekness of coat, less prominence of ligamentous and fibrous structures leading me to this conclusion, as well as the condition of the uteri of those females that I examined; they, I believe, had never borne young, and were not in pregnant condition.

Ross's seal is in form and size very like the Creamy White Seal (*Stenorhynchus carcinophaga*), but its coat is somewhat sleeker, of a beautiful pale mottled grey colour, darker on the back and lighter on the belly, and varying in intensity in different individuals. They were usually associated with the Creamy White Seals on the pack, and I found many to be with young. As descriptions of all these seals occur in Richardson and Gray's Catalogue of the specimens in the British Museum and elsewhere, and as specimens may be seen in the British Museum, in the College of Surgeons' Museum, in the Edinburgh Museum of Science and Art, and in the Dundee Museum, I need not delay by describing them, more than by saying that the longest Sea Leopard that was measured attained a length of over 13 feet. Also, that a rather striking, and not altogether inappropriate name was given to them by the sailors, who called them serpents, for they truly often presented a very serpent-like appearance. Dr Donald also noted that the females of the larger species were larger than the males; but beyond this there was no obvious sexual differentiation.

In December all the seals were in bad condition, thinly blubbered, and grievously scarred, and it is noteworthy that the females appeared to be as freely scarred as the males. During January their condition improved, and by February they were heavily blubbered and free of scars. The males were apparently as numerous as the females, but I made no definite statistics. Loving the sun, they lie on the pack all day digesting their meal of the previous night, which had consisted of fish or small crustaceans, or both; the penguin is also occasionally the victim of the Sea Leopard, and I have found stones in their stomachs. These stones are likely part of the geological collection which the penguins are accustomed to carry about with them. Nematode worms were almost invariably present in the stomachs.

By February the embryo is well developed, gestation probably beginning in December. It is extremely to be regretted that it was during this time that an indiscriminate slaughter took place, as almost every female, towards the end of January and in February, is with young. In no individual did I find more than one embryo.

All the seals were obtained from the pack ice, in bluest and clearest water, the Sea Leopard being on the outermost streams, and was most frequently found singly, but sometimes in pairs or threes on one piece of ice. Of Weddell's False Sea Leopards, we on board the "Balæna" only saw about four altogether, and these singly; Dr Donald, however, met with greater numbers. Two were quite young, and one of these we attempted to bring on board alive but failed.

The Creamy White Seals, the so-called Crab-Eating Seals, and the Mottled Grey Seals (Ross's Seal), were in greatest abundance; these lay four, five, or even ten on a single piece of pack ice; the greatest number I saw on one piece of ice at a time was forty-seven. On one occasion we found some seals on a tilted berg, and so high was the ledge above the level of the water that our men clambered up with difficulty and secured their prey. This illustrates their great power of jumping out of the water. I have seen them rising 8 or 10 feet above the sea, and cover distances of fully 20 feet in length.

The mode of progression of true seals is well known, but although on *terra firma* man can easily outrun them, yet on the pack they glide onward while their pursuer sinks deeply into the snow.

The present generation had never seen man, and at his approach they did not attempt to flee, but surveyed him open-mouthed and fearful, during which process they were laid low with club or bullet. Sometimes they are so lazy with sleep that I have seen a man dig them in the ribs with the muzzle of his gun, and, wondering what was disturbing their slumbers, they raised their head, only too quickly to fall pierced with a bullet. Seldom did they escape—one bullet meant one seal. On the last day of sealing we were among a great host of the large Sea Leopards, and as we were returning to the ship they were moaning loudly. This was said to be a sign that they were about to start on a long journey; but was it not rather a sigh of relief when they saw their slaughterers' craft run up her bunting, and announce to all that she was a full ship, and that her thirst for blood was quenched ?

While we continue to require sacks, while we persist in wearing patent leather shoes, and while we satisfy our fancies with certain purses and card-cases, the slaughter of these seals will continue. But I would here publicly protest against the *indiscriminate* massacre which takes place in order to supply blubber, as well as hides, for the purposes indicated. Old and young, females with young, are slaughtered alike, and should this continue, these seals, like the Antarctic Fur Seals at the beginning of the century, will undoubtedly be exterminated.

Of cetaceans we saw an immense number. We constantly met with great schools of dolphins and porpoises, as well as, on several occasions, with whales, but I must confess that I found identification very difficult. At Port Stanley I secured a ground porpoise, the skeleton of which is now in University College Museum, Dundee, and Mr Burn Murdoch has kindly lent me some drawings which he made on the spot, to show you this evening. It was a curious fact that in almost every case the schools of dolphins and porpoises were going, more or less, in the direction of the vessel, and one wonders if there were any particular reason for this. Was it migration? Were those we met with in October and November migrating southward at the approach of the northern winter, and were those we met with south of the line in November and December moving southward with the southern summer? Similarly, were those we met with in southern latitudes in March and April fleeing from the southern winter, and those that passed us in April and May going northward with the approach of the northern summer?

Whilst in the ice we met with three kinds of whales—Finners (probably *Physalis Australis*),[1] others strongly resembling the Pacific Hunchback Whale, and Bottle-nose Whale, two of which were captured by the Norwegian vessel. Besides these, there were present in considerable numbers grampus or sword-fish (*Orca*), conspicuous by its long dorsal fin. Ross says that in Erebus and Terror Gulf, on New Year's Day 1843, within one mile of the position we held on Christmas Eve 1892 (viz., in 64° S. 55° 28′ W.), "Great numbers of the largest sized black whales were lying upon the water in all directions: their enormous breadth quite astonished us." Elsewhere, also, he talks of a whale "greatly resembling, but said to be distinct from, the Greenland Whale."[2] It was chiefly upon the authority of these two statements, in addition to some others made by Ross, that the Dundee and Norwegian whaling fleet ventured to the south last year. None of the vessels saw any sign of a whale in the least resembling the Greenland or Bowhead Whale (*Balæna mysticetus*), although they were in the ice for a period extending over two months. Are we to conclude that Ross was mistaken, or has made a misleading statement? I think not. All we can say is that we failed to confirm Ross's statement, and that, on further search, the whale greatly resembling the Greenland whale may yet be found. We shall see whether the plucky little Norwegian craft that is pushing to 78° S., in the region of Victoria Land, has better luck this season.

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[1] Called "Blue Whales" by Captain Larsen of s.s. "Jason."

[2] "Ross's Voyage," vol. i., p. 169.

Ross says that the whales he saw were "*lying*" on the water, and this is one great characteristic of *Balæna mysticetus.* Contrary to the habits of the finner whales in the north, on more than one occasion we saw the southern finners also *lying* on the water, and sometimes the dorsal fin seemed to have been almost entirely torn away, perhaps by the ice. Could Ross have been thus deceived? Surely not, when he had had thirteen years' experience in Arctic Seas! Besides, he also adds "their enormous breadth quite astonished us." This is a second great characteristic. The Bowhead Whale has a great, broad, flat back, with a head one-third the total length of its body. These finners had a bony vertebral ridge, and very much smaller heads. Nor can we believe that Ross wished to mislead us, for in every way we found him a most faithful guide.

On the 16th of December, when we first made ice, we passed through thousands of finner whales. Many came quite close to the ship, and, as far as the eye could reach in all directions, one could see the curved backs and hear the resounding blasts. *Euphasia* swarmed in the water. Many blue petrels and myriads of Cape pigeons were flying around and settling in the water.

On the 26th of January, while out in a boat, I saw what at first appeared to be a rolling piece of ice, but what was in reality a white finner whale.

The whale which I have said strongly resembled the Pacific Hunchback Whale (*Megaptera versabilis*), I have seen going "tail up," a characteristic of the Bowhead Whale. It has a broader and flatter back than the finner whale mentioned, but can scarcely be said to resemble *Balæna mysticetus.*

XXVII. *Obituary Notice of the late Rev. George Gordon, LL.D., of Birnie.* By J. Horne, F.G.S., Geological Survey.

(Read 21st March 1894.)

The name of Dr Gordon has been intimately associated with the history of certain branches of local scientific research in the North of Scotland during the present century. Born in 1801 in the Manse of Urquhart, he was ordained as minister of the parish of Birnie in 1832, retiring in 1889 to Elgin to spend his closing years. His early observations were botanical; for in 1827 he is quoted as an authority on Northern Botany in Jamieson's *Edinburgh New Philosophical Journal.* In 1832, in the "Catalogue of Rarer Plants," Kew Library, he is mentioned as the discoverer of *Pyrola uniflora,* near Golspie. In the same year he forwarded to Murchison the first notice of the patch of Secondary Rocks at Linksfield, near Elgin, which appeared in the *Proceedings of the Geological Society.* In 1839 he published "The Flora of Moray," which embodied the results of work extending over several years. In one of these expeditions he discovered, on the Rosehaugh estate, *Pinguicula alpina*—a plant new to British botany.

His friendship with Dr Malcolmson led him to examine the Old Red Sandstone formation on the south side of the Moray Firth. His enthusiasm for this investigation was heightened by the publication of Hugh Miller's volume on "The Old Red Sandstone" in 1841, and by the subsequent discovery of reptilian remains in the Elgin sandstones. In 1858, chiefly by his unwearied exertions, a third reptile was obtained, named by Professor Huxley *Hyperodapedon Gordoni,* who pointed out that it is closely allied to the Triassic *Rhyncosaurus.*

While pursuing his geological observations, he found time for other researches, for between 1844 and 1860 he contributed several papers to the *Zoologist* on the fauna of his native province, including an exhaustive paper on the *Coleoptera* of Moray.

In 1859 he published his excellent paper "On the Geology of the Lower or Northern Part of the Province of Moray," in the *Edinburgh New Philosophical Journal,* and in that year the

University of Aberdeen conferred on him the degree of LL.D., in recognition of his services to local scientific research.

In 1862 he published a description of various shell-mounds on the south shore of the Moray Firth, in which his knowledge of the Mollusca is well shown.

But the subject which fascinated him most for the rest of his life was the development of our knowledge regarding the reptiliferous sandstones. By securing nearly every reptilian find, he aided Huxley in his investigations, and lately he was instrumental in sending to my colleague, Mr Newton, a series of reptilian remains, which, together with specimens in the hands of the Geological Survey, have been described in an elaborate memoir in the *Transactions of the Royal Society*. From this collection two forms of Dicynodonts have been obtained, one of the generic forms being named *Gordonia*, after Dr Gordon, and an extreme type of reptile allied to the South African *Pareiasaurus*.

XXVIII. *Notes on Carboniferous Lamellibranchs.* By J. G. GOODCHILD, H.M. Geological Survey, F.G.S., F.Z.S., M.B.O.U., Lecturer on Geology and Palæontology at the Heriot-Watt College.

(Read 21st March 1894.)

PART III. *Venus parallela*, Phillips, AND ITS ALLIES.

Through the kindness of Dr Traquair, I have had an opportunity of examining a good series of specimens from the Armstrong Collection in the Edinburgh Museum of Science and Art, which agree with Professor Phillips's descriptions and figures of *Venus parallela* (*Geol. Yorks.*, part ii., p. 209, pl. v., fig. 8). The Armstrong Collection includes some good testiferous specimens, which show both interiors and exteriors of shells referable to this species. In addition to studying these, I have examined several specimens of the same species and its allies in the Collection of the Geological Survey of Scotland, as well as others in various private collections. The results of the examination suggest that the fossil shells in question belong to the genus *Cypricardella* of Hall, *Trans. Alb. Inst.*, vol. iv., 1856.

In many respects these small Lamellibranchs show points of resemblance to *Pleurophorus*, and I am diposed to group them along with that genus under the Carditidæ.

Considerable diversity in external form may be noted in the examination of a large series of individuals. Taking external form as a basis for classification into species, we find the individuals in a large series of specimens ranging in two divisions. At one end of the series are those characterised by a sub-quadrate or a sub-rhombic contour of the shell margin; while at the other end of the series the same contours are sub-elliptical, or rather sub-ovate. Viewing types selected from either extreme of the series, the palæontologist might, apparently with good reason, regard these as perfectly good species, and as such, accordingly, they have generally been regarded, and have been designated *C. rhombea* and *C. parallela* respectively. But the occurrence along with these forms, in the same stratum, of shells presenting every intermediate gradation of form between the two extremes, is sufficient evidence to prove that we are dealing with a single species composed of individuals with a wide range of form.

For this species Phillips's original specific name of *parallela* may very well be retained; while for the sub-quadrate forms occurring at one extreme, the sub-specific or varietal name *rhombea* may be used as a trinomial, if so desired; while for the sub-ovate forms constituting the other extreme, those who care to mark the variety could employ the trinomial *ovata*, which would then rank as *Cypricardella parallela* var. *ovata*.

PART IV. BATHYMETRICAL DISTRIBUTION.

In dealing with extinct species of marine Invertebrata, the geologist has frequently occasion to search for evidence in regard to the conditions of depth under which certain species or assemblages of species may be supposed to have lived. The direct evidence bearing upon this question is not by any means generally satisfactory. But a certain amount of indirect evidence is obtainable, and this, in default of anything better, may serve, at least temporarily, as some kind of guide to the bathymetrical condition under which some of the commoner forms of Carboniferous Lamellibranchs may have lived.

The evidence is of this kind:—It is found by observation in the field that certain forms of these Mollusca occur either generally or else exclusively in strata of a particular lithological type. Certain species, for example, occur exclusively in pure limestones; others are restricted to argillaceous limestones and their associated calcareous shales; others again are found only in sandy shales; while yet a few others occur generally in sandstones. Those that occur in the one kind of deposit are rarely found to range into any one of the others. If we assume, as we appear to be justified in doing, that the sandstones represent the shallower water deposits formed nearest to the land, and that the limestones represent the strata formed farthest from the land, and, in general, in deeper water, then it follows that the forms of molluscan life occurring exclusively in pure limestones are those which lived at the greatest depths, those restricted to argillaceous and impure limestones and to the associated calcareous shales are such as lived at lesser depths, while the forms restricted to the arenaceous strata would appear to be safely regarded as comparatively shallow-water forms.

Taking the limestone forms first, we may note that *Conocardium*, *Cardiomorpha*, *Macrodon*, *Entolium*, and a small number of other Lamellibranch genera, are most commonly, or else exclusively, found in limestone. Then, in both impure limestones and calcareous shales occur *Sanguinolites*, *Allorisma*, *Edmondia*, *Lithodomus dactyloides*, *Pinna flabelliformis* and its allies, "*Inoceramus*," and some species of *Myalina*. In calcareous shales occur the great majority of the Carboniferous Lamellibranchs, including almost all the numerous species of *Aviculopecten*, *Anthracoptera*, *Anthracomya*, *Pteronites*, *Myalina*, *Nucula* and its sub-genera, *Schizodus*, *Pleurophorus*, *Cypricardella*, *Leptodomus*, *Sedgwickia*, and numerous others. Comparatively few species occur commonly in sandy shale, and this habitat seems to be almost peculiar to *Anthracosia*, which is almost certainly an estuarine and not a marine form.

XXIX. *Remarks on Two Transverse Sections of Carboniferous Wood from Baberton New Quarry, Midlothian.* By J. Bennie and J. A. Johnston.

(Read 21st February 1894.)

The pieces of petrified wood from which these sections have been made, were found lying on the shale heaps, having evidently been forced out of the softly indurated sandy shale as it crumbled into dust under exposure to the weather.

As it will characteristically introduce what we have to state regarding the quarry and the rocks in it, we may relate how we became acquainted with them. In course of conversation with Mr Samuel Hunter, builder, he told us that the sandstone of this quarry was so full of fossils that the stone was rendered useless by them—and that shortly after it had been opened by the late Sir James Gowans, he had to abandon working it for that reason. On visiting the quarry we soon saw the cause of this, inasmuch as the stone, a rather coarse sandstone, was full of impressions or imprints of plants which had once existed in bodily form, but had, in time, rotted, and been spirited away, leaving these hollow imprints behind. The stone, in quarrying or being divided into blocks suitable for building, would split or divide more readily in the direction of these imprints than in any other direction, and of course very seldom in the way the quarrier or builder wanted, and so they could not get stones of the necessary shape or size. This leads us naturally to understand the formation of the rock.

In early Carboniferous times there existed at the place we now call Baberton a lake or pool, or perhaps a wide reach of a river, or, say, simply a water into which a current flowed, carrying with it sand and mud and much drift-wood from the land of that time. These would be deposited very promiscuously in the sand and mud when it settled as sediment. Through time the sand set and hardened round the drift-wood, which would rot and pass away with the water which soaked through it, leaving a hollow imprint behind. This was the general fate of the drift-wood, but some pieces, through favourable circumstances, would be infiltrated by some of the preserving salts of Nature, probably silica in this instance, and would be made immortal by being petrified, and by having its structure as perfectly preserved as when it flourished in the forests of its time. It sometimes happened that some parts of the pieces of drift-wood putrified, as it were, and the structure was destroyed and the substance of the wood left in an amorphous state, as seen in the scurf of parrot-coal adhering to the outside of the specimens. The tree of which these sections were once parts is now, after a few aliases, known to fossil botanists by the name of *Araucaroxylon Withami*, and is considered to have been one of the stateliest monarchs of the woods of that time, as witness the fossil trees of Craigleith, described by Sir Robert Christison and others, good boles of which may be seen in front of the Museum of Science and Art in Chambers Street, and in front of the Herbarium, Royal Botanic Garden, Edinburgh.

It also may be interesting to detail roughly the strata exposed in the Baberton New Quarry. The main bed is the coarse sandstone, with its numerous impressions of drift-wood, about 20 feet or so in thickness; then a thin layer, only a few inches deep, of fire-clay, topped by a shallow seam of coal, perhaps not more than an inch in thickness; then 6 or 8 feet of coarsely coherent shale, in which thin layers of sandstone occur; then a bed of coarse-grained sandstone.

As fire-clays are now generally considered to have been old soils and coals (the remains of the vegetation that grew in or upon them), we have here evidence of a land-lake in which the great bed of sandstone and drift-wood was deposited till it was silted up and converted into dry land or perhaps marsh land, and capable of bearing a vegetation peculiar to its time or condition, and that afterwards it was again converted into a lake as before, but without the great amount of drift-wood that so emphatically characterises the older lake. This change is, we think, amply proved by the occurrence in the fire-clay of Lycopod spores, the cast-away seeds of the trees whose substance formed the coal, and further, by the frequent occurrence of *Stigmaria* roots in the fire-clay and in the silt of the second lake.

The general condition in which fossil wood is found varies very much, and, in a great measure, depends on the strata in which it is embedded. In many cases the wood is so completely carbonised as to show little or no evidence of cellular structure. Where the plant has undergone a process of mineralisation, usually with carbonate of calcium or silica, the structure is generally more or less preserved. To a certain extent pressure has often taken place, but even then the species of the plant to which the wood belonged can generally be recognised when thin slices are examined with the microscope.

In this specimen of *Araucaroxylon Withami*, from the Calciferous Sandstone Series at Baberton, we have a good example of a fossil stem, showing the cellular structure of the wood as well preserved as we would find in a section prepared from a living plant.

The interesting feature in connection with the Baberton specimen is the manner in which the wood has been fossilised. Only the cell-cavities are filled with silica, the cell-walls showing no evidence of the mineral, and, to all appearance, are merely carbonised. While on the other hand the contents of the cells exhibit, under polarised light, the characteristic colouring of crystalline quartz.

Mr Kidston has kindly supplied us with the following note on the subject:—"I have looked at the slices of wood from the Baberton New Quarry, and find the plant is the *Araucaroxylon Withami*, L. and H. sp. This generic name would *imply* an affinity with the modern *Araucaria*. Any close relationship to the latter genus is, I think, doubtful, and as I have elsewhere pointed out, that when we know the *Araucaroxylon Brandlingii*, L. and H. sp., to be the wood of *Cordaites*,[1] the probability is, that the other members of the genus *Araucaroxylon* may have the same relationship. There is the further indirect evidence pointing in the same direction, viz., that no remains, either of foliage or fruit, of any coniferous plant has ever, in this country, been found in the rocks which have yielded many stems of *A. Withami*, whereas, on the other hand, the same horizon has yielded *Cordaites* remains."

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[1] Grand' Eury, Flore carbon. du Départ. de la Loire, 1877, p. 257 *et seq.*

XXX. *The Land and Fresh-Water Crustacea of the District around Edinburgh.* Part III.—*The Cladocera.* By THOMAS SCOTT, F.L.S.

(Read 18th April 1894.)

In my two previous communications on the land and fresh-water Crustacea of the district around Edinburgh, I gave an account of the Amphipoda and Isopoda, and of the Ostracoda and Copepoda, that had been observed within the prescribed area. In the present paper I propose to deal with the Cladocera. Unfortunately, I have not been able to devote so much time to the study of this curious and troublesome, but very interesting, group of the Crustacea as it was my desire to do. It may therefore be necessary, later on, to prepare a supplementary paper, for the purpose of recording species belonging to the various groups that may yet be discovered in the district as the result of more extensive and careful investigation. It is scarcely possible that the lists I have prepared can be exhaustive, seeing that, comparatively, only a small portion of the district has been examined.

Two orders of the Crustacea—the PHYLLOPODA and the BRANCHIURA—are not yet, so far as I know, represented in the district around Edinburgh. I, at one time, thought that *Artemia salina* (the Brine Shrimp)—one of the Phyllopods—might be obtained within the district, where "salt-pans," past or present, existed; but after inquiring in various directions, no trace of this strange organism has been discovered. *Apus cancriformis*—another member of the Phyllopoda—is also absent from our district. Both *Apus* and *Artemia* are included in the British fauna. Though *Apus* is not now known to occur anywhere within the area around Edinburgh, or even in Scotland, the interesting discoveries of Mr James Bennie, of the Geological Survey, have shown that in ages long ago *Apus*[1] was a common Crustacean in what is now the neighbourhood of Edinburgh. Since there is, therefore, no doubt that *Apus* was common in our district sometime within the post-Tertiary period, why is it at present found only in the south and west of England, and is scarce even in these localities? If the *Apus* remains found by Mr Bennie belong to *Apus glacialis*, and there is reason to believe that they do, the reason why *Apus* was common in the post-Tertiary lake at Corstorphine, but is not known to occur anywhere in Scotland now, is not difficult to explain. *Apus glacialis* is a dweller in regions where an arctic or subarctic climate prevails, so, when the rigorous climate of our country, during the early portion of the post-Tertiary period, became gradually more and more temperate, *Apus glacialis* died out, just as *Pecten islandicus*, once so common in our seas, and the shells of which are so plentiful in some of the laminated clays of the west of Scotland, disappeared, and is only now found living in high latitudes. Mr Bennie discovered the remains of boreal plants in the same deposit with those *Apus*, and this strengthens still more the supposition that the fragments from the Corstorphine lake-deposit are those of the northern *Apus*. *Apus cancriformis*, on the other hand, has apparently a more southern distribution, which may account for it, also, not being found in Scotland. Though it is thus almost certain that no Phyllopods now exist in our district, I should not be surprised if *Argulus foliaceus*—the British representative of the Branchiura—may yet be found to be a member of the district fauna. *Argulus* is a parasite on various fresh-water fishes, as the trout, pike, carp, stickleback, etc. It is very depressed and round, and only about the one-fifth of an inch across, and as it sticks close on the skin of the fish, it may be easily overlooked. *Argulus* can swim freely when it chooses to do so, and may then be caught by tow-net, but usually it is obtained adhering to fish.

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[1] See Mr Bennie's paper in the Annals of Scottish Natural History, No. 9 (1894), p. 46.

The Cladocera obtained in the district around Edinburgh number twenty-nine species, and belong to twenty-two genera. In the following list the arrangement and nomenclature of C. L. Herrick's "Final Report on the Crustacea of Minnesota" is more or less adhered to. Dr Baird's classical work on the British Entomostraca, and the "Monograph of the British Entomostraca belonging to the families Bosminidæ, Macrothricidæ, and Lynceidæ," by the Rev. A. M. Norman and Dr G. S. Brady, have also been largely consulted. Various other papers on the Cladocera, both by British and Continental authors, have been made use of in determining the different species recorded in the list.

Order CLADOCERA.

Suborder **Calyptomera.**

Family SIDIDÆ.

Genus **Sida**, Straus.

Sida crystallina (O. F. Müller).

1776. *Daphne crystallina*, O. F. Müller, Zool. Dan. Prod., No. 2405.
1850. *Sida crystallina*, Baird, Brit. Entom., p. 107, pl. xii., figs. 3, 4; pl. xiii., fig. 1 *a-h*.

This large and fine species has only been obtained in one locality within the prescribed area, viz., in Raith Lake, Kirkcaldy, Fifeshire. I have records of the species for the following Scottish localities beyond our district:—Greenan Loch, Bute; Middle Loch (near the source of the river Lussa), Mull; Loch Awe, district of Assynt, Sutherlandshire; and Loch Tay, Perthshire.

Genus **Daphnella**, Baird.

Daphnella brachyura (Liévin).

1848. *Sida brachyura*, Liévin, Branch. d. Danziger Geg.
1850. *Daphnella wingii*, Baird, *op. cit.*, p. 109, pl. xiv., figs. 1-4.

Daphnella is much smaller than the last. It has been obtained in two localities within the district, viz., Loch Leven, Kinross-shire; and Raith Lake, Kirkcaldy. Also in the following Scottish localities beyond the limits of the district, viz., Middle Loch, Loch Scuban, Loch Ardglass, and Loch Uisg, all in the island of Mull. Greenock (M. F. Dunlop).

Family DAPHNIDÆ.

Genus **Ceriodaphnia,** Dana.

Ceriodaphnia reticulata (Jurine).

1820. *Monoculus reticulatus,* Jurine, Hist. Nat. Monoc., p. 139, pl. xiv., figs. 3, 4.
1850. *Daphnia reticulata,* Baird, *op. cit.*, p. 97, pl. vii., fig. 5; pl. xii., fig. 1 (♂), and fig. 2 (var.).

Raith Lake, Kirkcaldy, is the only locality within the district where this species has been obtained. I have records of its occurrence in the following localities beyond the area:—Loch Strathbeg, Aberdeenshire; Loch Eye, Ross-shire (East); and Middle Loch, Mull.

Genus **Scapholeberis,** Schödler.

Scapholeberis mucronata (O. F. Müller).

1776. *Daphne mucronata,* O. F. Müller, Zool. Dan. Prod., No. 2404.
1850. *Daphnia mucronata,* Baird, *op. cit.*, p. 99, pl. x., figs. 2, 3.

The only Scottish locality I know of for this species is Raith Lake, Kirkcaldy, where it was moderately common when I visited the loch in August 1890.

Genus **Simocephalus,** Schödler.

Simocephalus vetulus (O. F. Müller).

1776. *Daphne vetula,* Müller, Zool. Dan. Prod., No. 2399.
1850. *Daphnia vetula,* Baird, *op. cit.*, p. 95, pl. x., figs. 1, 1*a*.

This is evidently a more common species than the last. It has been obtained in Duddingston Loch, near Edinburgh; in Kilconquhar Loch, Raith Lake, and Lochgelly Loch, Fifeshire; and beyond the district, in Loch Strathbeg, Aberdeenshire.

Genus **Daphnia,** O. F. Müller.

Daphnia pulex (Linné).

1758. *Monoculus pulex,* Linné, Syst. Nat., 10th ed., vol. i., p. 635, No. 41.
1850. *Daphnia pulex,* Baird, *op. cit.*, p. 89, pl. vi., figs. 1-3.

Daphnia pulex has been obtained in Duddingston Loch, near Edinburgh; Raith Lake, Kirkcaldy; Loch Leven, Kinross; and in the following other Scottish lochs:—Loch Strathbeg, Aberdeenshire; Loch Achnacloich, Ross-shire (East); Loch Mullach Corrie, in Assynt, Sutherlandshire; and in Loch Harray, Orkney.

Daphnia longispina, O. F. Müller.

1785. *Daphnia longispina*, O. F. Müller, Entomostraca, p. 88, t. xii., figs. 8-10.

1850. *Daphnia pulex*, var. *longispina*, Baird, *op. cit.*, p. 89, pl. vii., figs. 3, 4.

This appears to be less common than *Daphnia pulex*. The only locality within the district where it was obtained was Loch Leven, Kinross-shire. It has also been observed in Loch Strathbeg, Aberdeenshire; and Loch Ness, Inverness-shire.

Family BOSMINIDÆ.

Genus **Bosmina**, Baird.

Bosmina longirostris (O. F. Müller).

1776. *Lynceus longirostris*, O. F. Müller, Zool. Dan. Prod., No. 2394.

1867. *Bosmina longirostris*, Norman and Brady, Nat. Hist. Trans. of Northumb. and Durham, vol. i., p. 357, pl. xxii., fig. 4.

Loch Leven is the only locality within the district where I have observed this *Bosmina*. But I have records of it from several other Scottish localities—Loch Ness, Inverness-shire; Loch Balnagowan, island of Lismore, Argyleshire; Loch Ardglass, Loch Scuban, Middle Loch, Mull; Loch Ascog, Bute; a small loch near Rutherglen, Lanarkshire; Loch Tay, Perthshire.

Family LYNCODAPHNIDÆ, Sars (1861).

Genus **Ilyocryptus**, G. O. Sars.

Ilyocryptus sordidus (Liévin).

1858. *Acanthocercus sordidus*, Liévin.

1861. *Ilyocryptus sordidus*, G. O. Sars, Om de i Omegnen af Christi. forekom. Clad., p. 11.

This species is usually more or less coated with mud, from its habitat being among mud at the roots of aquatic plants, and is thus very liable to be overlooked. *Ilyocryptus sordidus* has been obtained in three localities within the district around Edinburgh, viz., Lochend Loch, where it was common; Loch Leven; and in a ditch by the side of Harelaw Dam,—the first and last localities are in the vicinity of Edinburgh. I have also records of its occurrence in Loch Morar, Inverness-shire; Loch Tay, Perthshire; and in a small loch near Rutherglen, Lanarkshire. Greenock (M. F. Dunlop).

Family LYNCEIDÆ.

Genus **Eurycercus**, Baird.

Eurycercus lamellatus (O. F. Müller).

1776. *Lynceus lamellatus*, O. F. Müller, Zool. Dan. Prod., No. 8396.
1850. *Eurycercus lamellatus*, Baird, *op. cit.*, p. 124, pl. xv., fig. 1.

Eurycercus is comparatively a common species. I have obtained it in Duddingston Loch, Raith Lake, Lochgelly Loch, and Loch Leven. The following are some of the localities beyond the prescribed area where I have obtained it:—Goldenhoof Dam, near Howietoun, Stirlingshire; Loch Strathbeg, Aberdeenshire; Loch Morar, Inverness-shire; Loch Scuban and Loch Ardglass, island of Mull, Argyleshire; Loch Tay, Perthshire; and the Paisley Canal, Renfrewshire.

Genus **Acroperus**, Baird.

Acroperus harpæ, Baird.

1835. *Lynceus harpæ*, Baird, Trans. Berw. Nat. Club, vol. i., p. 100, pl. ii., fig. 17.
1841. *Lynceus leucocephalus*, Koch, Deutsch. Crust. (Myriap. u Arach.), p. 36, pl. x.
1850. *Acroperus harpæ*, Baird, Brit. Entom., p. 129, pl. xvi., fig. 5.

Baird's name for this species has clear priority over that of Koch. *Acroperus harpæ* is a moderately common species. It has been obtained in Duddingston Loch; in Raith Lake, Camilla Loch and Lochgelly Loch, Fifeshire; and in Loch Leven, Kinross-shire. Also in the following among other localities beyond the district:—Goldenhoof Dam, near Howietoun, Stirlingshire; Loch Tay, Perthshire; Loch Scuban, Mull; and a small loch near Rutherglen, Lanarkshire.

Genus **Alonopsis**, G. O. Sars.

Alonopsis elongata, G. O. Sars.

1862. *Alonopsis elongata*, G. O. Sars, Om. de i Omeg. af Christi. forekom. Clad., Andet Bidrag., p. 41.
1867. *Lynceus elongatus*, Norman and Brady, Mon. of the Brit. Entom., p. 376, pl. xviii., fig. 1; pl. xxi., fig. 2.
1884. *Alonopsis elongata*, Herrick, Crust. of Minnesota, p. 85.

The only locality within the district for which I have a record of this species is Loch Leven, but I think it will yet be obtained in other fresh-water localities around Edinburgh, because it is by no means a rare Cladoceran. I have *Alonopsis* from several places beyond the prescribed area—as Loch Tay, Perthshire; Loch Mullach Corrie, Sutherlandshire; Loch Scuban, island of Mull, etc.

Genus **Leydigia**, Kurz.

Leydigia quadrangularis (Leydig).

1860. *Lynceus quadrangularis*, Leydig, Naturges. der Daphn., p. 221, pl. viii., fig. 59.
? *Leydigia quadrangularis*, Kurz, Dodekas Neuer Cladoceren.
1891. *Leydigia quadrangularis*, T. Scott, Ninth Ann. Report, p. iii., p. 292, pl. ii., figs. 5 *a*, *b*.

I recorded this species in the *Ninth Annual Report of the Fishery Board for Scotland* (1891), as having been obtained in Lochgelly Loch, Fifeshire, and it has occurred nowhere else within the district. Last year Mr James Steel, Glasgow, presented me with some material he had collected in a small loch near Rutherglen, Lanarkshire; there were several interesting things in this material, and one of them was *Leydigia quadrangularis.* I do not know of any other Scottish record for this species.

Genus **Graptoleberis**, G. O. Sars.

Graptoleberis testudinarius (Fischer).

1851. *Lynceus testudinarius*, Fischer, Mem. des Sav. étrangers, St Petersbourg, vol. vi., p. 191, pl. ix., figs. 3-6.
1862. *Graptoleberis testudinarius*, G. O. Sars, *op. cit.*, p. 41.

I obtained this curious little species in Lochend Loch, Edinburgh, and this is the only locality within the district where *Graptoleberis* has been observed. I have it also from Loch Tay, Perthshire; from Loch Mullach Corrie, Sutherlandshire; and from Loch Morar, Inverness-shire.

Genus Alona, Baird.

Alona guttata, G. O. Sars.

1862. *Alona guttata*, G. O. Sars, *op. cit.*, p. 38.
1867. *Lynceus guttatus*, Norman and Brady, Mon. Brit. Entom., p. 380, pl. xviii., fig. 6; pl. xxi., fig. 10.
1884. *Alona guttata*, Herrick, Crustacea of Minnesota, p. 94.

I have only one record for this species in the district, viz., for Camilla Loch, Fifeshire. It is almost certain to occur in other localities, as it has a fairly wide distribution, but being small it is easily overlooked. I have records of its occurrence in Loch Tay, Loch Mullach Corrie, and Loch Morar.

Alona tenuicaudis, G. O. Sars.

1862. *Alona tenuicaudis*, G. O. Sars, *op. cit.*, p. 37.
1867. *Lynceus tenuicaudis*, Norman and Brady, *op. cit.*, p. 376, pl. xix., fig. 3.
1884. *Alona tenuicaudis*, Herrick, *op. cit.*, p. 95, pl. i., fig. 2.

I have this from the same locality as the last, viz., Camilla Loch, and I know of no other Scottish record for *Alona tenuicaudis*. It is distinguished from other *Lynceidæ* by the slender form and armature of the post-abdomen.

Alona costata, G. O. Sars.

1862. *Alona costata*, G. O. Sars, *op. cit.*, p. 38.
1867. *Lynceus costatus*, Norman and Brady, *op. cit.*, p. 379, pl. xviii., fig. 2; pl. xxi., fig. 7.
1884. *Alona costata*, Herrick, *op. cit.*, p. 94.

Alona costata has been obtained in two localities within the district, viz., Lochgelly Loch, and in a ditch by the side of Harelaw Dam. The only other record I have for this species is for Loch Morar, Inverness-shire.

Alona quadrangularis (Müller).

1776. *Lynceus quadrangularis*, O. F. Müller, Zool. Dan. Prod., p. 199, No. 2393.
1850. *Alona quadrangularis*, Baird, Brit. Entom., p. 131, pl. xvi., fig. 4.

This moderately common species was obtained in Raith Lake, Camilla Loch, and Lochgelly Loch, Fifeshire; and in Loch Leven, Kinross-shire. I have it also from Loch Tay, Loch Mullach Corrie, Loch Morar, small lochs in the island of Mull, etc.

Genus Alonella, G. O. Sars.

Alonella exigua (Lilljeborg).

1853. *Lynceus exiguus*, Lilljeborg, De Crust. in Scania occur., p. 79, pl. vii., figs. 9, 10.
? 1862. *Alonella excisa*, G. O. Sars, *op. cit.*, p. 52.
1884. *Alonella exigua*, Herrick, *op. cit.*, p. 105.

Loch Leven, frequent along the north and south shores. I have no record of this species for any other locality within the prescribed area. *Alonella exigua* was obtained in Loch Morar, Inverness-shire; and Loch Hempriggs, Caithness-shire.

Alonella nana (Baird).

1843. *Acroperus nanus*, Baird, Ann. and Mag. Nat. Hist., vol. ii., p. 92, pl. iii., fig. 8.
1862. *Alonella pygmæa*, G. O. Sars, *op. cit.*, p. 52.
1884. *Alonella pygmæa*, Herrick, *op. cit.*, p. 105, pl. H., fig. 7.

Alonella nana has been obtained in two localities within the district around Edinburgh, viz., Raith Lake, Kirkcaldy; and Loch Leven. I have *Alonella nana* also from Loch Morar. This is a very small species, being only about ·25 mm. ($\frac{1}{100}$ of an inch); it is therefore easily overlooked. Seen under a moderately high power of the microscope, the sculpture of the skull of this species is very pretty; it has a distinct and more or less regular fluted appearance, the striæ are obliquely transverse, extending downwards from the front in more or less regular curved lines.

Genus **Peracantha**, Baird.

Peracantha truncata (O. F. Müller).

1781. *Lynceus truncatus*, O. F. Müller, Entomostraca, p. 75, pl. ii., 4-6.
1850. *Peracantha truncata*, Baird, Brit. Entom., p. 136, pl. xvi., fig. 1.

Lochgelly Loch, Fifeshire, is the only locality within the prescribed area where this species was obtained. I have records of it from two localities beyond our district, viz., Loch Morar, Inverness-shire; and Loch Scuban, in the island of Mull. *Peracantha truncata* was frequent in the material from the Mull loch.

Genus **Pleuroxus**, Baird.

Pleuroxus lævis, G. O. Sars.

1861. *Pleuroxus lævis*, G. O. Sars, Om. de i Omeg. af Christi. forekom. Clad., p. 22.
1862. *Pleuroxus hastatus*, idem, *ibid.*, Andet Bedrag., p. 52.
1867. *Lynceus lævis*, Norman and Brady, Mon. Brit. Entom. belonging to the Bosmin. Macrothric. and Lynce., p. 38, pl. xviii., fig. 5; pl. xxi., fig. 14.

Pleuroxus lævis was obtained only in Camilla Loch, Fifeshire, where it occurred sparingly.

Pleuroxus trigonellus (O. F. Müller).

1776. *Lynceus trigonellus*, O. F. Müller, Zool. Dan. Prod., No. 2395.
1850. *Pleuroxus trigonellus*, Baird, Brit. Entom., p. 134, pl. xvii., fig. 3 (♀).
,, *Pleuroxus hamatus*, idem, *ibid.*, p. 136, pl. xvii., fig. 5 (♂).

This species appears to be more common than the last. It has been obtained in two localities within our area, viz., Raith Lake, Kirkcaldy; and Loch Leven, Kinross. Other localities where I have records of its occurrence are Loch Strathbeg, Aberdeenshire; and Loch Tay, Perthshire.

Pleuroxus uncinatus, Baird.

1850. *Pleuroxus uncinatus*, Baird, *op. cit.*, p. 135, pl. xvii., fig. 4.
1884. *Pleuroxus uncinatus*, Herrick, Crustacea of Minnesota, p. 114.

This was obtained in the same two localities as the last species—Raith Lake, and Loch Leven. It was also obtained in a small loch near Rutherglen, Lanarkshire.

Genus **Chydorus**, Baird.

Chydorus sphæricus (O. F. Müller).

1776. *Lynceus sphæricus*, O. F. Müller, Zool. Dan. Prod., No. 2392.
1850. *Chydorus sphæricus*, Baird, *op. cit.*, p. 126, pl. xvi., fig. 8.

This is one of the commonest species among the Cladocera. I have it from Duddingston Loch; Raith Lake, Kirkcaldy; Camilla Loch, and Lochgelly Loch; Loch Leven; Clubbiedean Reservoir, near Edinburgh, etc. And the following among other Scottish localities—Loch Tay, Perthshire; Loch Achnacloich, East Ross-shire; Loch Mullach Corrie, Sutherlandshire; Loch Morar, Inverness-shire; lochs on the island of Lismore, Argyleshire; small loch near Rutherglen, Lanarkshire; Black Loch, Dunbar, Haddingtonshire, etc., etc.

Genus **Monospilis**, G. O. Sars.

Monospilis tenuirostris (Fischer).

1854. *Lynceus tenuirostris*, Fischer, Bull. de Soc. Imp. des Nat. de Moscou, p. 427, pl. M., figs. 7-10.
1861. *Monospilis dispar*, G. O. Sars, Om. de i Omeg. af Christi. forekom. Clad., p. 23.
1867. *Monospilis tenuirostris*, Norman and Brady, *op. cit.*, p. 52, pl. xix., fig 2; pl. xx., fig. 9.

This is a remarkable Cladoceran; instead of casting its shell during the process of ecdysis, each new shell is formed inside of, and is coalesced with, the older one, and being somewhat larger it projects beyond the margin of the older shell. When the animal has undergone several ecdyses, the outer portion of the shell bears a number of concentric lines very like the growth-lines seen in various Lamellibranch Molluscan shells.

This curious species was frequent in one or two places on the south shore of Loch Leven, Kinross. I have no record of *Monospilis* for any other locality in Scotland.

Suborder **Gymnomera**.

Family POLYPHEMIDÆ.

Genus **Polyphemus**, O. F. Müller.

Polyphemus pediculus (Linné).

1746. *Monoculus pediculus*, Linné, Faun. Suec., No. 2048.
1776. *Polyphemus pediculus*, O. F. Müller, Zool. Dan. Prod., No. 2417.
1850. *Polyphemus pediculus*, Baird, Brit. Entom., p. 111, pl. xvii., fig. 1.

Polyphemus was obtained in Raith Lake and in Loch Leven. This species seems to have a preference for moderately large sheets of water. It was frequent in Loch Ness, Loch Oich, and Loch Lochy in 1890; abundant in Loch Morar in 1892; frequent in Loch Tay in 1893; and in Middle Loch, island of Mull.

Genus **Bythotrephes**, Leydig.

Bythotrephes longimanus, Leydig.

Bythotrephis longimanus possesses an enormously long post-abdominal spine; it has otherwise somewhat the aspect of a *Polyphemus*. The only locality within the area where it has been obtained is Loch Leven, Kinross-shire. I found it common in Loch Ness and Loch Oich; frequent in Loch Morar; and rather scarce in Loch Tay. I have also notes of its occurrence in Loch Scuban and Middle Loch, island of Mull.

Family LEPTODORIDÆ.

Genus **Leptodora**, Lilljeborg.

Leptodora hyalina, Lilljeborg.

This beautiful species was obtained in Loch Leven, but nowhere else within the district. It was moderately common in some of the tow-net gatherings from that loch. I also found it frequent in Loch Morar tow-net gatherings, and also in those made in Loch Tay. The Rev. A. M. Norman obtained it in Lochmaben Loch, Dumfriesshire. When alive, its presence in the water can only be detected by the black pigment-spot that constitutes the creature's eye. *Leptodora* is a large Cladoceran; some of my specimens from Loch Leven measure at least three-eighths of an inch in length, but with the exception of the black eye-spot it is perfectly transparent; hence, though by no means rare in Britain, it had been overlooked even by such a careful observer as Dr Baird, and was only discovered when the Rev. A. M. Norman examined Lochmaben Loch, a locality that had previously been examined by Dr Baird.

With *Leptodora hyalina* I complete my list of the fresh-water Cladocera observed within the district around Edinburgh; and this also finishes, for the present, my enumeration of the land and fresh-water Crustacea of the area.

In my first paper I recorded one Amphipod and nine Isopods, and in the second paper thirty-five Ostracods and twenty-one Copepods, for the district; in the present paper I have recorded twenty-nine species of Cladocera, making the total number of species of land and fresh-water Crustacea recorded for the district around Edinburgh ninety-five. This number is likely to be considerably augmented when the district comes to be more thoroughly investigated.

It may be of interest to those not familiar with the Entomostraca, if, before leaving this part of my subject, I should indicate one marked and characteristic difference in the manner in which the reproduction of the species is accomplished in each of the three large groups of the Entomostraca dealt with in the preceding lists, viz., the Ostracoda, the Copepoda, and the Cladocera.

The Ostracoda may be described as the "oviparous group." In this group the eggs are usually deposited on floating or submerged leaves of aquatic plants, pieces of wood, etc., or on stones at the bottom, and are left there to hatch out, without apparently any further parental care.

The Copepoda and Cladocera, on the other hand, may be described as the "ovoviviparous groups," but with this difference between them. In the Copepoda the eggs are usually deposited in either one or two—but never more than two—little external sacs—the ovisacs—which are attached to the genital segment of the abdomen, and are in communication with the oviducts, so that the eggs, as they are successively matured within the body of the animal, pass into them. The ovisacs, especially when there are two of them, one on each side of the abdomen, as in *Cyclops*, enhance the graceful appearance and beauty of the little creatures, as they are usually more or less, and, occasionally, even brilliantly coloured. In the Cladocera the eggs are carried in an ovigerous chamber situated within the posterior portion of the sort of bivalve test with which many species are furnished, as for example in *Daphnia*, or within a dorsal sac formed by an outgrowth of the dorsal surface, as in *Polyphemus* or *Bythotrephes*. But whether the eggs are carried in ovisacs, as among the Copepoda, or in an ovigerous chamber, as among the Cladocera, they remain in these receptacles till the young are hatched. These two groups thus differ very markedly from the Ostracoda. The so-called winter eggs of the Cladocera are enclosed in a portion of the parental test, or in a special covering formed by the parent Cladoceran, and then becoming detached within this specialised covering or ephippium, they fall to the bottom and remain there till the season favourable for their development arrives. Of course there are exceptions, and, if the marine species belonging to the three groups were included, very peculiar exceptions, to the characteristic differences I have tried briefly to indicate; but as I am only dealing at present with the fresh- and brackish-water species, the exceptions are fewer.

One serious trouble experienced by the student of the fresh-water Crustacea, and especially of the Copepoda, is the large number that are to be met with in all stages of development; and as the penultimate, or antepenultimate, stage of one species frequently closely resembles the mature stage of another and different species, the greatest vigilance is necessary to avoid mistaking the young stage of one species for the adult stage of another; the surest course to adopt is to discard all specimens except those where the females are bearing ovisacs, as the possession of these is usually an indication of maturity.

I now propose, by way of conclusion to the present paper, to append a list of Scottish species of Cladocera that have not yet been observed in the district around Edinburgh, together with a note of a few of the localities where each has been obtained; such a list will be useful for comparison, and will indicate the blanks that have yet to be filled up, ere we have a complete list for the district.

A LIST OF SCOTTISH SPECIES OF CLADOCERA NOT YET OBSERVED IN THE DISTRICT AROUND EDINBURGH.

Holopedium gibberum, Zaddach. This has been obtained in Loch Ness and in Loch Morar, Inverness-shire. (In Beith's Dam, and in a reservoir behind the Cut, at Greenock—M. F. Dunlop, Greenock.)

Daphnia Jardinii, Baird. Frequent in Loch Ness, Inverness-shire; and in Loch Tay, Perthshire.

Bosmina longispina, Leydig. Loch Skene, Dumfriesshire (G. S. Brady); Stornoway, Lewis (A. M. Normân); Loch Balnagowan, Lismore Island, Argyleshire.

Bosmina coregoni, Baird. Lochmaben Castle Loch, Dumfriesshire. This curious species forms a considerable part of the food of the vendace (*Coregonus albula*)—a rare British fresh-water fish found in Lochmaben Loch.

Macrothrix laticornis (Jurine). This was obtained in Loch Morar (1892); also in North Shaws Loch, Selkirkshire (G. S. Brady, 1867).

Macrothrix rosea (Jurine). Lochmaben Loch, Dumfriesshire (Sir W. Jardine, Bart., and Mr W. Yarrell).

Drepanothrix dentata, Euren. (*D. hamata*, Sars). Lochend Loch, Kirkcudbrightshire; and Loch Skene and Lochmaben Loch, Dumfriesshire (G. S. Brady).

Acantholeberis curvirostris (O. F. Müller). Found in a tarn in the island of Cumbrae, by Mr David Robertson.

Camptocercus macrurus (O. F. Müller). This was obtained in Loch Morar, Inverness-shire; Loch Tay, Perthshire; and Loch Scuban, island of Mull, Argyleshire; near

Stornoway, island of Lewis (Rev. A. M. Norman); Alemoor and North Shaws Lochs, Selkirkshire; and Lochmaben Loch, Dumfriesshire (Dr G. S. Brady); Paisley Canal (Mr David Robertson).

Leptorhynchus falcatus (G. O. Sars). Loch Morar, Inverness-shire. Dr G. S. Brady obtained it in Lochend Loch, Kirkcudbrightshire; and Lochmaben Castle Loch, Dumfriesshire.

Chydorus globosus, Baird. Paisley Canal (D. Robertson); Loch Balnagowan, island of Lismore, Argyleshire; Loch Scuban, island of Mull.

Anchistropus emarginatus, G. O. Sars. In the Paisley Canal, Renfrewshire (Mr David Robertson). Herrick states that it is just possible this may be the male form of *Chydorus globosus* ("Crust. of Minnesota," p. 118).

It will be observed from the preceding supplementary list, that twelve species, recorded from various parts of Scotland, have not yet been obtained in the district around Edinburgh. But it is almost certain that, at least, some of them will be discovered within our area, when it comes to be more thoroughly examined.

XXXI. *A Contribution to the Vertebrate Fauna of West Ross-shire.* By LIONEL W. HINXMAN, B.A., and WILLIAM EAGLE CLARKE, F.L.S., etc.

(Read 18th April 1894.)

Although material for a complete review of the Vertebrates of the Faunal Area of West Ross is not at the present time available, we have thought it desirable to place on record, in these short notes, the results of our personal observations in the districts of Torridon, Applecross, and Strathcarron during the past few summers, supplemented by the information obtained from keepers and others in various parts of the area. And here we gladly take the opportunity of expressing our thanks for the valuable assistance willingly rendered by Mr W. Macdonald, Torridon; Mr Donald Matheson, Kinloch, Shieldaig; Mr W. Angus, Strath-na-Shallag; Mr John Stuart, Applecross; and Mr Kenneth Maclean, Kinlochdamph.

The Faunal Area of West Ross has received very little attention from naturalists, while the central and southern portions, which are more particularly treated of in this paper, have been especially unfortunate in this respect, and hence the writers have thought it desirable to offer this slight contribution to their natural history. The northern section of the area has been more favoured. It has several excellent resident naturalists, whose labours are gathered together in Mr Dixon's interesting "Gairloch," to which our readers are referred for much information relating to that portion of West Ross-shire.

Area under consideration.—The area to which these notes refer may, for convenience of description, be divided into four districts, named as follows:—

(1) *Dundonnell*—extending from the southern boundary of Cromartyshire, immediately south of Glen Achall, to the watershed between the two Gruinard rivers, and including the ground drained by the streams flowing into the two Loch Brooms and the eastern side of Gruinard Bay.

(2) *Gairloch*—the country drained by the Little Gruinard, Loch Maree, the head-waters of the Ewe, and the streams flowing into the Gairloch, and including Rudha Mor and the North Point—the two promontories on either side of Loch Ewe.

(3) *Applecross*—comprising the peninsula of that name, together with the ground round the head of Loch Torridon, drained by the Kishorn, Balgy, and Torridon rivers.

(4) *Strathcarron and Lochalsh*—the south-western part of the county, drained by the Carron, Ling, Elchaig and Shiel, and other streams flowing into Lochalsh.

Physical Features.—The physical configuration of West Ross does not favour the presence of an abundant or varied fauna. It is emphatically a mountainous region, and includes some of the wildest and most rugged scenery of the West Highlands. Fully two-thirds of the area has an elevation of 1000 feet and upwards above sea-level; fifty-six mountains reach a height of between 2500 and 3500 feet, twenty-seven of which exceed 3000 feet, and it is only in the north-west, round the Gairloch, and on the North Point, that any considerable extent of ground below 500 feet in elevation is to be found. The greater part of West Ross is, in fact, a high mountain plateau, carved by the forces of denudation into a hundred forms of ridge and hollow, deep corrie and shattered summit-peak, and trenched by narrow valleys in which flow the principal streams. These valleys are continued below sea-level as narrow sea-lochs, which penetrate far up among the hills; while the still further incursion of the sea at an earlier period is indicated by the fragments of raised beaches, seen as flat terraces of shingle, that occur here and there at the mouths of the glens, and along the sides of the sea-lochs. From the shores of most of these lochs the hills rise steeply almost from the water's edge, as at the head of Loch Torridon, where from the beach the eye ranges directly upwards to the summit of Leagach, 3400 feet overhead.

The eastern boundary of West Ross follows the watershed of Scotland, running with a sinuous course, but general southerly trend, from Glen Achall, north of Loch Broom, to Beinn Loyne at the head of Glen Clunie, where it meets the northern limit of Inverness-shire, which extends W.N.W. to the coast at Glenelg. Nowhere is the watershed at a greater distance than 15 miles from the nearest point of the western sea-board. The rivers are, consequently, insignificant in length, and—with the exception of the Ewe, which drains the great reservoir of Loch Maree—of little volume, save after heavy rains, when they come down with great rapidity and often devastating effect. Of these the principal are the Broom; the Strathbeg in Dundonnell; the Big and Little Gruinards, running respectively into Little Loch Broom and Gruinard Bay; the Ewe with its headwaters the Garbh and Breachaig, running into and draining Loch Maree; the Kerry at Gairloch; the Torridon and Balgy flowing into Loch Torridon; the Carron; and the Ling, Elchaig, and Shiel flowing into Lochalsh.

In all these rivers salmon and sea-trout are found at some time during the year, and there are few of the larger burns up which sea-trout, and now and then a grilse or two, do not run when there is water to carry them, though in many cases they are prevented by falls from getting any distance from the sea.

None of the West Ross streams can be called *early* rivers, and except in the Ewe and Balgy the run of fish, even in the later spring months, is very small, the bulk of the grilse and sea-trout not coming up till the first spates of June. The exception in the case of the two rivers mentioned is, no doubt, due to their having a short course to the sea out of large lochs—Loch Maree and Loch Damph—in which the temperature of the water is, in some degree, raised and brought nearer to that of the Atlantic than in those streams which flow directly from the mountains, and are fed by the melting snows of spring.

Lochs.—Freshwater lochs are very numerous and of every size, from the alpine tarn high up in the mountain corrie, or the dark pools of the peaty flats, to the wide expanse of Loch Maree with its clustered, wooded islets, the breeding-places of Gulls, Divers, and possibly a few pairs of Grey-lag Geese.

Salmon and sea-trout are found in greater or less numbers in the following lochs:—Na Sheallag in Dundonnell; Maree, Coulin, Clair, and Varanaich in Gairloch; Iasgaich at the head of Glen Torridon; Damph and Coultrie on the Balgy; Doule in Glen Shieldaig; Dhugaill and Sgamhain in Strathcarron.

All those lochs in uninterrupted communication with the sea hold brown trout, varying much in size and quality, while into some others, apparently inaccessible, they have been introduced by human or other agency.

Char occur in Loch Maree and three or four other small lochs in the Gairloch area, in Loch Damph, Loch ram Fiadh in Torridon, and Lochans Uaine and Corrie Lair in the Achnashellach Forest. In the three last-mentioned localities they are of quite recent introduction.

Pike are found in the river Kerry and Lochs Feur and Bad-na-Sgalaig in Gairloch, where they were introduced early in the present century.

The larger lochs—Maree, Fionn, and Damph—sometimes reward the angler with large specimens of the so-called

Salmo "ferox," but less frequently we believe of late years. Indeed, there is general complaint of the falling off in numbers of all kinds of fish, the causes assigned being the superabundance of bag-nets along the coast, and poaching at the heads of the sea-lochs in the case of the migratory fish; while the decrease in the brown trout is supposed by some to be due to the substitution of sheep for cattle on the hills.

Woods.—The wooded areas are few and far between, and, as a rule, of very limited extent. The natural woods are mostly birch, with a few alders along the lower stream courses. The lower part of the Dundonnell Glen is well clothed with birch, and on the hillsides the trees extend to a height of over 1000 feet, while round Dundonnell House there are many fine timber trees—beeches, limes, chestnuts, and walnuts—planted some hundred years ago.

The foot and sides of Loch Maree are more or less fringed with natural wood, and at Glas Leitire, as well as about Loch Clair, there are some fine specimens of ancient pines, relics of the primæval forest. At Flowerdale, Kernsary, and Kerrisdale, there is also a considerable extent of wood, both natural and planted, the latter including hardwood and conifers. Farther to the south small patches of natural birch wood occur along the southern shores of Loch Torridon, in Glen Shieldaig, Glen Kishorn, and at Applecross, where there are also considerable plantations, and some timber trees of large size.

The greatest extent of planted wood is found at Leckmelm and Braemore on Loch Broom. Here large plantations of conifers have lately been formed, Sir John Fowler having, we believe, put in as many as six millions of trees on his estates at the latter place. At Achnashellach, in Strathcarron, there are also plantations of recent date.

These additions to the wooded area of the district are likely, in the near future, to have an important influence on the avifauna of the country. Certain woodland birds, now scarce and local, or only occurring as chance visitants, may be expected to become common and general, and new forms may be added to the list of indigenous species.

Climate and Rainfall.—The climate is that common to the west coast of Scotland,—mild and humid, with a mean annual temperature ranging from 46·4 to 46·6 degrees.

The prevailing westerly and south-westerly winds are generally accompanied by mist and rain—easterly winds bring dry, and in summer often very hot weather.

The winters are usually mild, and snow does not often lie long on the low grounds. The rainfall is excessive. The table given below shows the annual and mean rainfall during six years at five stations, fairly distributed over the district from north to south. It will be seen that only at Applecross and Strome Ferry is the mean fall below 60 inches. Both of these are coast stations, situated opposite to and at no great distance from the hills of Skye, which to a certain extent drain the clouds before they reach the mainland.

At Torridon and Glen Carron, situated in narrow glens among lofty mountains, the mean ranges from 78 up to nearly 89 inches, and at the latter station reached the high figure of 109 inches in the wet season of 1890.

That this excessive rainfall probably affects, both directly and indirectly, the abundance and distribution of certain species, will be shown later on.

	Height above Sea-level.	RAINFALL IN INCHES.						
		1887.	1888.	1889.	1890.	1891.	1892.	**Mean of Six Years.**
Loch Broom, .	Sea-level	61·11	61·71	61·43	66·82	61·54	57·50	61·58
Loch Torridon,	Sea-level	71·09	74·88	70·56	82·88	88·58	81·73	78·28
Applecross, .	Sea-level	42·99	53·44	46·41	63·44	57·46	56·63	53·39
Glen Carron, .	500	80·27	80·80	79·71	109·78	90·23	91·78	88·76
Strome Ferry,	Sea-level	54·79	56·76	51·83	62·88	60·81	57·52	57·42
	Mean of all the Stations, ...							67·88

Geology.—It is perhaps hardly necessary to call attention to the intimate connection that exists between the geology and animal life of every district. The mutual interdependence of plant, insect, and bird life, and the obvious influence of the geological features of a country upon its *flora*, alone render these features of importance when considering its *fauna*, while in other less direct ways peculiarities of rock-structure, soil, and glacial phenomena may be shown to be important factors in determining the presence and distribution of certain species.

A general sketch of the geology of West Ross, with special reference to the points more directly affecting its faunal character, may then, be not altogether out of place.

A glance at the most recent geological map of Scotland shows that the rocks of West Ross arrange themselves in three well-marked zones of varying breadth, running parallel to the western coast in a N.N.E. to S.S.W. direction.

These are (beginning in the west),—

1. *The Pre-Cambrian Zone*—including the Archæan or Lewisian Gneiss and the Torridon Sandstone.
2. *The Cambrian Zone.*
3. *The Eastern Schist Zone.*

1. *The Pre-Cambrian Zone.*—The Lewisian Gneiss occupies a large area in Gairloch and Dundonnell, extending from Talladale and Shieldaig south of Loch Maree to the coast on the east side of Gruinard Bay. Isolated patches of gneiss also occur on both sides of Loch Torridon at the narrows, and extend along the southern shore of the outer loch as far as Arrin-na-chruineach.

This gneiss, generally conceded to be the most ancient rock in the British Isles, is of an exceedingly tough and uncompromising character, yielding little to the forces of atmospheric denudation, and hence peculiarly well fitted to preserve the traces of glacial action, traces nowhere so distinctly visible as in the seaward parts of West Sutherland and West Ross. The country where the Lewisian Gneiss prevails is consequently for the most part bare and rocky, with ice-smoothed hummocky ridges succeeding one another in dreary monotony. Generally barren of soil and herbage, there is little in these regions to attract bird-life. The innumerable small lochans, often partly covered with weeds and water-lilies, that fill the ice-carved rocky hollows, afford, however, breeding ground for a few pairs of Lesser Grebes and Red and Black-throated Divers; while the islets in the larger lochs are often occupied by a colony of Common Gulls, or a single pair of Greater Blackbacks, or sometimes, when wooded, by a heronry, where the ungainly birds look strangely out of proportion to the stunted birch and holly trees in which their nests are placed.

Immediately to the north of Loch Maree, and round the head of the Fionn Loch, the gneiss rises to a considerable height, forming the rugged mountains of Airidh à Charr, Ben Lair, Beinn à Chaisgain, and the Maighdean, whose mural precipices are the resort of the Golden Eagle, the Peregrine, and—until within the last few years—of the White-tailed Erne.

The Torridon Sandstone, or Torridonian, as it is now called, rests unconformably upon the gneiss, filling up the hollows and lapping over the lower hills of the ancient land surface. It is chiefly made up of purple and chocolate-coloured gritty sandstones, with local developments of dark shales, flagstones, and basal conglomerate or breccia. These rocks occupy the greater part of Gairloch and Dundonnell, and nearly the whole of Applecross, and form some of the most striking scenery of the West Coast. The spiry cones of An Teallach, the spear-shaped crest of Slioch, the splintered ridge of Leagach—all rising to heights of upwards of 3250 feet—together with Alligin, Ben Dearg, Ben Bhan, and a host of minor peaks—belong to this formation; and on their terraced cliffs of sandstone, whose regular bedding gives the effect of courses of cyclopæan masonry, most of the remaining pairs of Eagles, Buzzards, Peregrines, and Ravens in the district find a more or less secure nesting-place.

But apart from the mountain peaks and precipices, the lower hill-slopes and less elevated moorlands sloping to the sea, that are included in the Torridonian area, have a peculiar character induced by the structure of the underlying rocks. The successive outcrops of sandstone, horizontal or dipping gently in one uniform direction over large areas, form a succession of terraces, flat or inclined at a low angle, that follow each other in parallel lines along the contour of the hill-slopes. On the higher ground these terraces are usually bare, and strewn with carried boulders. Lower down they become masked by a thin covering of peaty soil, thus producing a succession of shallow, trough-like hollows. In wet weather the water is prevented to a great degree from following the natural drainage lines, owing to the fact that these hollows lie across the general slope of the ground. They thus become completely water-logged, and after two or three days of rain the only dry spots over large areas will be the tussocks of coarse grass that rise above the sodden ground. In a region of such excessive rainfall this may well account in great measure for the scarcity and stunted character of the heather over a large extent of the district, and consequently affect the number of the birds that depend upon heather for cover and food supply. To the same cause may be attributed the scarcity of such birds as the Curlew, Golden and Green Plover, Redshank, and other waders on these moorlands in the breeding season, a scarcity in striking contrast with their abundance on the drier hillsides of the Central and Eastern Highlands.

2. *Cambrian Zone.*—The Cambrian rocks form a belt, usually not more than a mile or two in breadth, that extends from Ullapool on Loch Broom to the heads of Lochs Kishorn and Carron. The principal member of this series is the white quartzite, which is seen capping most of the higher mountain tops along the line from An Teallach to Ruadh Stac in Strathcarron, and reaches its greatest development in Ben Eighe, whose bare glittering scree-slopes and serrated ridges form one of the most striking features in that wonderful panorama of loch and mountain which opens to the view from the head of Glen Docherty. This quartzite is a very siliceous, hard, and splintery rock. It breaks up into large angular fragments, produces little or no soil, and is therefore inimical to plant and animal life. In fact, no mountain tops are so utterly barren and lifeless as those covered with the Cambrian quartzite. Yet it is amongst the tumbled screes, composed of angular blocks of all sizes, which skirt the highest quartzite peaks, that the Snow Bunting is to be looked for in the breeding season in West Ross; and it may well be that among these scenes of desolation the bird finds the nearest approach to the arctic solitudes it loves so well.

Associated with the quartzite is a band of limestone which crops out here and there along the line between Loch Broom and the head of Loch Kishorn. The outcrops are generally interrupted and of little breadth, and it is only along the eastern side of Glen Kishorn that this rock covers any extent of ground. But wherever it occurs there is an immediate change in the character of the country. Rich herbage and an abundance of flowering plants, many of which are peculiar to a limestone soil, clothe the ground; insect life swarms, and there is a corresponding increase in the number and variety of the smaller birds, especially of those species which are insectivorous. It is a great contrast to pass from the barren quartzite ridges that rise above Glen Kishorn, where the Ptarmigan's croak and the hoarse bark of the Raven are the only sounds to be heard, to the lower limestone slopes, rich in vegetation, where the air is filled with the incessant notes of Wheatear and Whinchat, and diversified by belts of natural wood resounding with the song of Thrush and Blackbird, Redstart, Willow-Wren, and Tree-Pipit, and the calls of Cole-Tits and Chaffinches.

3. *The Eastern Schist Zone.*—The eastern schists fringe the eastern side of the Dundonnell area, and extending southwards, occupy the greater part of Strathcarron and Lochalsh. Composed chiefly of different varieties of quartzose and micaceous schist and gneiss, they are generally richer in alumina than the rocks to the west, and consequently yield more readily to atmospheric weathering, with an accompanying production of a thin soil of sandy clay. The country where these rocks occur is therefore for the most part fairly well clothed with grass and heather.

Our acquaintance with this part of West Ross is at present very limited, but it will probably be found that the bird-life in this region approximates more closely to that of the heathery moorlands of the Central and Eastern Highlands.

Glaciation.—Nowhere in Scotland are the traces of the Glacial Period more distinctly marked than in the area under consideration, and especially in Torridon, Applecross, and the western side of Strathcarron. The great ice-sheet, travelling seawards from a centre of dispersion that lay considerably to the eastwards of the present watershed, has left the unmistakable footprints of its course in the smoothed and striated rock-surfaces, strewn with perched boulders, that are found everywhere on the shoulders and ridges, and even in some cases on the very summits of the hills.

The later valley glaciers that marked the close of the Glacial Period, have further swept out the detrital drift and boulder-clay left behind by the ice-sheet, leaving the bottoms and sides of the valleys bared to the rocky floor, with here and there only a fringe or group of barren, stony moraines.

The ground suitable for cultivation is therefore of very limited extent, and the arable lands are mostly confined to the raised beaches at the heads and along the shores of the sea-lochs, and to the alluvial deltas of the larger streams. Hence the birds usually associated with cultivation, such as the House Sparrow, Corn Bunting, Partridge, and Landrail, are extremely local in their distribution, and almost entirely confined to the coast-line. The streams flowing through these rocky glens carry little sediment to the sea, and even when in heavy flood will, from the nature of the rocks over which they flow, be charged only with coarse sand and shingle. There are consequently no muddy foreshores to attract the waders, no ooze-banks covered with *zostera* for the sea-ducks and wild geese. Both these classes of birds are in fact thinly and locally distributed, and the latter appear only to visit the shores in any numbers under stress of weather in winter.

On the shingle beaches however, Arctic Terns, Oyster-Catchers, and Ringed Plover breed in considerable numbers; while the long range of rocky coast and scattered islets afford nesting sites for Rock-Doves, Gulls, Shags, and a few Black Guillemots, though there are no great breeding colonies of Guillemots and Puffins, such as those found farther to the north on the lofty cliffs of West Sutherland.

THE FAUNA.

It has been mentioned that the districts under consideration include some of the wildest and most rugged country in the Western Highlands.

In such an area it might naturally have been expected that some of the rarer species of carnivorous mammals, such as the Wild Cat, the Marten, the Polecat, and the Badger, might find an asylum wherein they would be, to some extent at least, free from that relentless persecution which is slowly but surely effecting their extermination in Britain. It is disappointing to make known the fact that such is not the case. Even in remote West Ross these species are now not only exceedingly rare, but on the very verge of extinction. While the day of these rare furred carnivores is past and gone, yet, thanks to the protecting influence of the deer forests, through their sanctuarial character, their feathered prototypes the Golden Eagle, the Buzzard, the Peregrine Falcon, and the Merlin, still abide in some numbers. Thanks also to the same protecting cause, the Black and Red-throated Divers still find a summer retreat in the forest lochs.

A remarkable feature in the ornithology of West Ross is the almost entire absence of bird-life over wide stretches of country. On the moorlands birds are singularly sparsely scattered; and though the Red Grouse, the Curlew, the Golden Plover, the Greenshank, the Ring Ouzel, and the Meadow Pipit are represented, yet in certain districts one may walk for hours over what would elsewhere be suitable haunts for these species, without catching a glimpse of their forms or being made aware of their presence through their cries. Nor is bird-life more abundantly represented in the valleys and lowlands of Torridon and Applecross. Indeed, we find such common and characteristic species as the Lapwing and the Skylark so extremely limited in their numbers, and so very local in their distribution, that a casual visitor would almost be justified in regarding them as absent; and yet localities eminently suitable—to all appearance—for these and other species are many.

The cause of this remarkable dearth of ground-building species among birds is not, we think, far to seek, and has already been alluded to in our remarks upon the climatic and geological peculiarities of the area. Thus the rainfall we know to be excessive; while the nature and lie of the rocks is over large areas unfavourable to an effective surface drainage. The effect of these conditions is most prejudicial to the chances of the chick-life of the species named. Many broods must be completely drowned out, while in others only a very small proportion of the normal number would survive the many dangers of such a morass-like nursery. The result is that no increase accrues to the breeding stock; indeed, in some species, as the Red and Black Grouse, the numbers are said to be on the decline.

With the woodland species, on the other hand, the conditions of life would seem to be the reverse of unfavourable. The wooded portions are not very considerable, and are often widely separate, yet they are veritable oases of bird-life. There are, however, some notable absentees among common arboreal species, birds which do not, as yet, seem to have sought a home in the woodlands, and among others the Magpie and the Great Titmouse may be mentioned here. Indeed, West Ross affords an opening for colonists; and it may be remarked in this connection that the Rabbit, the Starling, the Rook, and even the Sparrow, are among recent immigrants whose advent has been duly chronicled, and which are, as yet, far from numerous or general. Hence it is not unlikely that other species, now unknown to the area, will in course of time become established within its limits.

MAMMALIA.

The unfortunate status of some of the more interesting and rarer mammals has already been alluded to; and all the necessary particulars relating to the 27 species of this class which are known to us as inhabiting or visiting the districts under consideration will be found in detail in the annotated list which forms the concluding section of this contribution. It may, however, be remarked that within the last few days we have examined a specimen of the Bank Vole, which is not only an addition to the fauna of Ross-shire, but the most northerly record for the species in Britain.

The following is a summary of the Mammalia of the district:—

Chiroptera, . . .	1	species.
Insectivora, . . .	4	,,
Carnivora, . . .	9	,,
Cetacea, . . .	2	,,
Ungulata, . . .	2	,,
Rodentia, . . .	9	,,
	27	,,

AVES.

Of the 132 species of birds which have come under our notice, or which have been reported to us, no less than 91 breed annually within the area, while 11 only of this total take the rank of casual visitors. No doubt many rare birds have from time to time visited, and do visit, West Ross-shire, but the number of the resident naturalists is so small that most of these pass unnoticed.

We have already made some allusion to the birds in the general remarks on the fauna and elsewhere, and as each species is treated of in the annotated list that follows, little remains to be said regarding them. There are, however, a few species deserving special mention.

The White-tailed Eagle, which for some years has been considered to be extinct as a resident species on the mainland of Great Britain, we have good authority for saying nested in the district down to 1889, and may, perhaps, still survive.

The Snow Bunting is another rare resident worthy of notice. Some common and generally distributed species are quite rare, and we can only account for such being the case on the supposition that they are perhaps recent colonists. These are the Sedge Warbler, Great Titmouse, Blue Titmouse, Greenfinch, Jackdaw, etc.

As regards the movements of migratory birds, the coast of West Ross-shire does not lie in the course of the main West Coast stream, which appears to be very much confined to the shores and isles of the Minch and the Little Minch. The

British Association Committee on the Migration of Birds, were furnished with returns from the lighthouse on South Rona, situated off the coast of West Ross, and midway between its shores and those of the Isle of Skye, and the data supplied make it quite evident that little or no migration occurs there.

The avifauna of the districts, as known to us, may be summarised as follows:—

Residents,	72	Breeding species.
Summer visitants,	19	
Winter visitants,	23	
Visitors on migration,	3	
Casuals,	11	
Hypothetical,	4	
Total avifauna,	132	

MAMMALIA.

Vespertilio pipistrellus (*Schreb.*). PIPISTRELLE.

Fairly common in wooded districts. This is the only species of Bat that has been identified.

Erinaceus europæus, *Linn.* HEDGEHOG.

A Hedgehog was killed at Fasag, at the head of Loch Torridon, in the winter of 1891, and was supposed to have come from Achnasheen, where they occur sparingly. Not known in Dundonnell or Applecross.

Talpa europæa, *Linn.* MOLE.

Generally abundant. First appeared in Applecross about the year 1842, and is now very numerous there. Found high up on green spots in the hills, Dundonnell.

Sorex tetragonurus, *Herman.* COMMON SHREW.

Sorex minutus, *Linn.* LESSER SHREW.

One specimen obtained at Ob Meallaidh, Shieldaig, in 1892.

Felis catus, *Linn.* WILD CAT.

Very scarce, but not yet quite extinct in Dundonnell and Applecross. Formerly very plentiful, but rapidly decreasing in numbers during the last twenty years. Two were trapped in Dundonnell during the spring of 1891; and one, a very fine specimen, at Fisherfield in 1890. The last Wild Cat trapped by Donald Matheson in Shieldaig was in 1886, up to which date he was getting from one to five every season. Specimens—a male and a female—in the Museum of Science and Art, Edinburgh, were obtained at Strome Ferry in the year 1884.

Canis vulpes, *Linn.* FOX.

Generally distributed and abundant. Enjoys a certain amount of protection in the deer forests.

Mustela martes, *Linn.* MARTEN.

Has become extremely rare during the last few years. Not seen in Shieldaig since 1885. A female was trapped at the Black Rock on Loch Damph in January 1893, and another killed at Kinlochewe in February of the same year. Supposed to be extinct or nearly so in Dundonnell; the last one heard of in this district was trapped by Wm. Morrison about twenty-six years ago. Very rare now in Applecross. One killed in 1893.

Mustela vulgaris, *Erxl.* WEASEL.

Fairly abundant, but not so numerous as the next species.

Mustela erminea, *Linn.* STOAT.

Generally distributed, and fairly common in all districts.

Mustela putorius, *Linn.* POLECAT.

Becoming extremely scarce, but still occasionally met with in Dundonnell. No record from Applecross.

Lutra vulgaris, *Erxl.* OTTER.

Probably more abundant than is generally supposed, owing to its retiring habits. Fairly numerous in Torridon, about the islands and wooded margins of the sea-lochs. Frequently met with in Dundonnell, though hardly to be called abundant.

Meles taxus (*Schreb.*). BADGER.

Appears to be quite extinct in all districts. Not obtained at Shieldaig since about the year 1850, and disappeared from Applecross about the same date. Formerly plentiful in Dundonnell, but now believed to be extinct, the last having been trapped by W. Morrison in Gruinard about 1867.

Phoca vitulina, *Linn.* COMMON SEAL.

A few frequent Loch Torridon. Often seen in Little Loch Broom, Gruinard Bay, and other sea-lochs.

Halichœrus gryphus (*Fab.*). GREY SEAL.

A large seal, probably attributable to this species, was killed in Loch Torridon a few years ago.

Globicephalus melas (*Trail*). PILOT WHALE.

Frequently met with in small schools in Loch Torridon.

Phocœna communis (*F. Cuv.*). PORPOISE.

Abundant off the coast, and often seen in the sea-lochs.

Cervus elaphus, *Linn.* RED DEER.

The greater part of West Ross being under forest, Red Deer are abundant throughout, and believed to be increasing. The following forests are included in the area:—Rhidoeroch (part of), Dundonnell, Gruinard, Fisherfield and Letterewe, Kinlochewe, Flowerdale, Shieldaig, Torridon, Ben Damph, Glen Shieldaig, Applecross, New Kelso, Coulin, Achnashellach, and parts of Attadale, Kintail, and Dorisduan. The deer are reported to be increasing very much on Fisherfield, where the average number is estimated at about 4000. Average number on Applecross said to be about 2000.

Capreolus capræa, *Gray*. Roe Deer.

Fairly common in all the wooded districts, but said to be scarce in Dundonnell and Fisherfield. Average number at Applecross about 80.

Mus sylvaticus, *Linn.* Long-tailed Field Mouse.

Generally distributed, and abundant in all suitable localities.

Mus musculus, *Linn.* House Mouse.

Universally distributed, and abundant wherever there are houses.

Mus decumanus, *Pallas.* Brown Rat.

Abundant everywhere. Found among the rocks on the sea-shore, and occurs on Inverbain Island in Loch Torridon, and on one, if not more, of the Summer Isles.

Arvicola amphibia (*Linn.*). Water Vole.

Generally present, and abundant on the margins of streams and lochs suited to its habits. The melanic variety, as is usual throughout the Highlands, is the characteristic form; and indeed the ordinary brown race is regarded as only of casual occurrence, and is not even known in Dundonnell and Applecross, where the black variety is very common.

Arvicola agrestis, *De Selys.* Field Vole.

Generally distributed, and plentiful among the rough grass on the moorlands and hillsides. A vole, probably of this species, was observed on the summit of Ben Bhan, at an elevation of 2750 feet, in June 1892.

Arvicola glareolus (*Schreb.*). Bank Vole.

A fine male specimen was received by Messrs Macleay of Inverness from Sir John Fowler of Braemore in April 1894, and was examined by us while in the flesh. This occurrence of *A. glareolus* at Braemore is believed to be the most northerly record for this species in Britain.

Lepus europæus, *Pallas*. COMMON HARE.

Thinly distributed on the low grounds, and decreasing in numbers since the appearance of rabbits. Said to be quite extinct in Dundonnell. A few still present in Fisherfield.

Lepus variabilis, *Pallas*. VARYING HARE.

Abundant, and found down to sea-level in Applecross. Said to be decreasing very much of late years in Dundonnell, but, on the contrary, increasing in Applecross.

Lepus cuniculus, *Linn.* RABBIT.

Of comparatively recent introduction, but now generally abundant in all suitable localities. First introduced at Shieldaig about the years 1867-70. Fairly numerous in Dundonnell, but date of appearance not known. First appeared at Applecross in 1878, and are increasing.

AVES.

Turdus viscivorus, *Linn.* MISSEL THRUSH.

Thinly distributed in wooded districts.

Turdus musicus, *Linn.* SONG THRUSH.

Resident. Fairly abundant where there is wood or cultivated ground, and increasing. One or more of the thrushes in the woods at the head of Loch Shieldaig were noticed to have caught the alarm note of the Oyster-Catcher and other shore birds, frequently introducing an exact imitation into their song.

Turdus iliacus, *Linn.* REDWING.

Turdus pilaris, *Linn.* FIELDFARE.

These two species are chiefly observed during the period of autumn migration; and when the rowan berries are abundant, linger to avail themselves of these, their favourite food, before passing south.

Turdus merula, *Linn.* BLACKBIRD.

Fairly plentiful, but not so numerous as *T. musicus.* Increasing of late years in Applecross.

Turdus torquatus, *Linn.* RING OUZEL.

Summer visitant. Thinly distributed throughout on the rocky hillsides, and found nearly to the summit of the highest mountains.

Cinclus aquaticus, *Bechst.* COMMON DIPPER.

Generally distributed, and fairly common both on streams and lochs, but not nearly so abundant as on the eastern side of the watershed.

Saxicola œnanthe (*Linn.*). WHEATEAR.

Summer visitant, generally distributed and common, but varying in numbers from year to year. Thus in the years 1889-91 this and the two following species were very abundant, but in 1892 there was a marked falling off in their numbers, in fact, the Stonechat did not come under observation in the Applecross district.

Pratincola rubetra (*Linn.*). WHINCHAT.

Summer visitant, varying much in numbers.

Pratincola rubicola (*Linn.*). STONECHAT.

Local, and varying in numbers. Found with the preceding species in the valleys, but also ascends to a considerable height on the mountain sides.

Ruticilla phœnicurus (*Linn.*). REDSTART.

Generally distributed in the wooded districts, and next to the Willow Wren the most abundant summer visitant among the woodland birds, but also varies in number from year to year. Particularly numerous in 1891.

Erithacus rubecula (*Linn.*). REDBREAST.

Generally distributed, and abundant in the wooded districts.

Sylvia cinerea (*Bechst.*). WHITETHROAT.

Thinly distributed in bushy places, but not common, and confined to low elevations near the sea. Applecross, Torridon, Kishorn.

Regulus cristatus, *Koch.* GOLDEN-CRESTED WREN.

Fairly common as a resident, wherever there are conifers.

Phylloscopus trochilus (*Linn.*). WILLOW WREN.

Summer visitant. Abundant everywhere in suitable localities. By far the most common of the woodland summer birds. A pair will be found wherever a few birches clothe the hillside.

Phylloscopus sibilatrix (*Bechst.*). WOOD WREN.

Summer visitant. This species, which has hitherto not been recorded as observed in West Ross, was seen and heard on several occasions during the early summer of 1892 in the woods at the head of Loch Shieldaig, and at Arrin-na-chruinneach, on the southern shore of Outer Loch Torridon. This fact is an important addition to the existing evidence as to the distribution of the Wood Wren in Britain, no record of the bird so far to the north-west having been before obtained.

Acrocephalus schœnobænus (*Linn.*). SEDGE WARBLER.

Summer visitant, rare and local. Only observed at the head of Loch Torridon, and at Courthill, Kishorn.

Accentor modularis (*Linn.*). HEDGE SPARROW.

Abundant, and found in the most unlikely situations, as the rocky sea-shores, or on islets in mountain lochs.

Parus major, *Linn.* GREAT TITMOUSE.

Rare. Observed only at Shieldaig, and in woods on Loch Damph.

Parus cœruleus, *Linn.* BLUE TITMOUSE.

Not common. Found nesting at Torridon and Shieldaig.

Parus britannicus, *Sharpe and Dresser.* ENGLISH COAL TITMOUSE.

Abundant in all wooded localities. The Tit of the district.

Certhia familiaris, *Linn.* CREEPER.

Thinly distributed where there are trees of any size.

Troglodytes parvulus, *Koch.* WREN.

Common, and found in the wildest and rockiest localities.

Motacilla lugubris, *Temm.* PIED WAGTAIL.

Local, and not numerous. A pair found nesting in June 1892 on the cliffs of Eilean Mhòr, a rocky islet in Outer Loch Torridon, in close proximity to a colony of the Herring Gull.

Motacilla melanope, *Pallas.* GREY WAGTAIL.

Rare. Only observed at Shieldaig and Courthill, Loch Kishorn.

Anthus pratensis (*Linn.*). MEADOW PIPIT.

Everywhere very abundant on the moors and hillsides, and found almost to the summits of the highest mountains.

Anthus trivialis (*Linn.*). TREE PIPIT.

Summer visitant. Fairly abundant in the wooded districts.

Anthus obscurus (*Lath.*). ROCK PIPIT.

Resident and common along the rocky shores, where it breeds, and also on most of the islands in Outer Loch Torridon.

Oriolus galbula, *Linn.* GOLDEN ORIOLE.

Seen at Inverewe about the year 1883 by Mr Osgood Mackenzie. Another specimen shot on Loch Broom some years previously.

Ampelis garrulus, *Linn.* WAXWING.

Seen in the garden at Letterewe early in March 1893 by Mr Osgood Mackenzie.

Muscicapa grisola, *Linn.* SPOTTED FLYCATCHER.

Summer visitant. Fairly numerous. The nest is often placed on a ledge of rock in the woods, sometimes in a similar situation on the margin of the sea-lochs.

Hirundo rustica, *Linn.* SWALLOW.

A rare transient visitor only. Solitary birds observed in June in various localities.

Cotile riparia (*Linn.*). SAND MARTIN.

Very local, and far from numerous. A few pairs nest in the river bank at the head of Loch Torridon. Also at Applecross.

Ligurinus chloris (*Linn.*). GREENFINCH.

Appears to be an uncommon resident. Only observed in 1890 at Shieldaig. Perhaps a recent colonist.

Passer domesticus, *Linn.* COMMON SPARROW.

Local resident, but seems to be rapidly increasing in numbers and extent of range. In most districts of West Ross of recent colonisation only. Not known previous to the year 1887 at Shieldaig, where it is now abundant.

Fringilla cœlebs, *Linn.* CHAFFINCH.

Very abundant. Perhaps the most common resident woodland species.

Linota cannabina (*Linn.*). LINNET.

Resident, not common, and local. Only observed at the head of Loch Torridon.

Linota flavirostris (*Linn.*). TWITE.

Resident. Very abundant everywhere. Breeds in the long heather on the hillsides.

Pyrrhula europæa, *Vieill.* BULLFINCH.

Well represented in the wooded districts, and extending its range with the increase of plantations. Not known previous to the year 1885 at Torridon House, where it is now numerous. Common in Dundonnell, less so in Fisherfield. Resident.

Loxia curvirostra, *Linn.* COMMON CROSSBILL.

Resident in the Gairloch district.

Emberiza miliaria, *Linn.* COMMON BUNTING.

Abundant where there is cultivated land, especially at the head of Loch Torridon, where it outnumbers *E. citrinella.* Resident.

Emberiza citrinella, *Linn.* YELLOW BUNTING.

Abundant and resident where there is cultivation, and also not unfrequently found in the woods.

Emberiza schœniclus, *Linn.* REED BUNTING.

Resident, fairly common, but local. Observed at Torridon, Shieldaig, and Applecross, nesting among heather on the margin of lochs and ditches.

Plectrophanes nivalis (*Linn.*). SNOW BUNTING.

Winter visitant, but a few pairs each year remain to breed on the higher mountain tops.

The breeding range of the Snow Bunting in the Highlands is unquestionably of much greater extent than was suspected until within the last few years. In the year 1886, the first nest recorded for the mainland of Scotland was found by one of the authors in the Assynt district of West Sutherland. Since that time three or four nests at least have been obtained in the same locality, and in 1893 one was also recorded for the first time from the Banffshire Cairngorms (see *Ann. Scot. Nat. Hist.*, 1893, p. 181).

In West Ross we have not as yet actually seen the nest, or heard of its being taken by others, but the birds have been repeatedly seen in summer on the highest peaks in the Fisherfield, Kinlochewe, Ben Damph, and Applecross forests; while in July 1889 Snow Buntings were watched through binoculars feeding fully-fledged young on a mountain-top in the Torridon forest.

From the inaccessibility and rugged nature of the ground which the birds frequent—usually the loose quartzite scree slopes on the highest and most difficult parts of the mountain,—they may very easily escape observation, and it is probable that few of the higher mountains in West Ross, where the ground is suitable, are without a pair or two of Snow Buntings during the breeding season.

Alauda arvensis, *Linn.* SKYLARK.

Very local, and seems to be confined to the grass-lands at the heads of the sea-lochs, and even there not found in places apparently suitable. Entirely absent from the moorlands. Said to be decreasing in Applecross.

Sturnus vulgaris, *Linn.* COMMON STARLING.

Very local, but seems to be rapidly spreading. Has only appeared in some districts during the last few years. Not known at Shieldaig prior to 1890. Five or six pairs were observed nesting in the cliffs of Eilean Mhor, Outer Loch

Torridon, in June 1892. Said to have come to Applecross about the year 1883. Reported common in Fisherfield, especially in flocks in the autumn. Resident.

Pastor roseus (*Linn.*). ROSE-COLOURED PASTOR.

An adult male specimen was shot some years ago at the head of Loch Torridon. The bird had been noticed for some days previously, feeding amongst and alighting on the backs of sheep, in company with common Starlings. This specimen was preserved, and is now in the possession of Mr Darroch of Torridon.

Pica rustica (*Scopoli*). MAGPIE.

On the authority of Donald Matheson, a pair of Magpies nested many years ago at Culags, in Strathcarron. A pair were also seen at Inveran, on Loch Maree, in the winter of 1891.

Corvus monedula, *Linn.* JACKDAW.

Resident, very local, but probably increasing in distribution. The only breeding-site known to us is at Applecross, where about a dozen pairs were found nesting in a limestone scar above the village in June 1892.

Corvus cornix, *Linn.* HOODED CROW.

Though relentlessly persecuted, still maintains its position as a fairly common resident species, and most abundant in the vicinity of the coast-line. A specimen with a patch of grey between the shoulders, and the back black—thus having the appearance of a hybrid between this species and *C. corone*, a species that has not come under notice in the district—was observed on the shore of Loch Torridon in 1892. Two specimens with similar colouring were also seen in the "keeper's larder" at Applecross in the same year.

Corvus frugilegus, *Linn.* ROOK.

There are rookeries at Dundonnell, Gairloch, Tullich in Strathcarron, and Applecross. The birds travel long distances to feed, and often roost in large numbers on Shieldaig Island in July and August, ten miles from the nearest colony. Rooks are reported to have first come to Applecross about 1863, and to have become very destructive of recent years, taking both eggs and young of grouse, and also sometimes carrying off young ducklings, chickens, and even goslings.

Corvus corax, *Linn.* RAVEN.

Though the numbers of this species have been reduced to a low limit through constant persecution, it now enjoys a certain amount of immunity from molestation, and a few pairs still haunt the recesses of the deer forests. A pair have bred for many years, and still nest, on Sron na Fithich (The Raven's Nose), at the western end of Ben Shieldaig, above the village. Reported as still fairly common in Applecross, but decreasing.

Caprimulgus europæus, *Linn.* COMMON NIGHTJAR.

Summer visitant, rare and local. Occurs every year in the wood at the head of Loch Shieldaig, arriving early in June. The nest has been taken at Applecross.

Upupa epops, *Linn.* HOOPOE.

The Rev. E. S. Marshall records one, shot on the shore near Loch Duich in September 1877 (see *Ann. Scot. Nat. Hist.*, 1894, p. 113).

Cuculus canorus, *Linn.* CUCKOO.

A common and generally distributed summer visitant.

Strix flammea, *Linn.* BARN OWL.

Resident, not common, and very local. Breeds on Shieldaig Island.

Syrnium aluco (*Linn.*). TAWNY OWL.

A common resident in all the wooded districts.

Asio accipitrinus (*Pallas*). SHORT-EARED OWL.

A nest, which may most probably be ascribed to this species, was found among the heather on the hillside in Glen Shieldaig some years ago, from which the young were taken.

Circus cyaneus (*Linn.*). HEN-HARRIER.

Appears to be now very rare. Reported as sometimes seen in Dundonnell, but becoming very scarce.

Buteo vulgaris, *Leach.* COMMON BUZZARD.

Resident, thinly distributed, and decreasing in numbers. Nests annually on several mountains in the Applecross district. Nested near the head of Loch Carron in 1893. There is a handsome, light-coloured variety in the Museum of Science and Art, Edinburgh, which was obtained in the Shieldaig forest in the autumn of 1893.

Aquila chrysætus (*Linn.*). GOLDEN EAGLE.

Thanks to the protection of the proprietors, this species has not decreased in numbers of late years, and a few pairs breed annually in Dundonnell, Gairloch, and Applecross. Without particularising the localities of the different eyries, we may mention the existence of two in the Dundonnell forest; two in Fisherfield, where the eagles are reported to be increasing; at least three in the neighbourhood of Loch Maree; one in Ben Damph forest; and perhaps as many as five in Applecross.

Haliætus albicilla (*Linn.*). SEA-EAGLE.

Probably now extinct as a resident species. On the authority of Wm. Macdonald, head-keeper, Torridon, a pair of sea-eagles nested up to the year 1889—when his acquaintance with the locality ceased—in the Ben Damph forest. Nothing, however, was seen of these birds in 1890-91. An adult was trapped about 1880 in Glen Shieldaig, and released after being kept for some weeks in confinement. Reported as occasionally seen in Fisherfield. John Stuart, Applecross, reports three as seen there in the winter of 1893.

Accipiter nisus (*Linn.*). Sparrow Hawk.

Appears to be a somewhat rare resident in Applecross. A pair nested on Shieldaig Island in 1892. Not detected by the keepers in Torridon and Applecross.

Milvus ictinus, *Savigny*. Kite.

Reported as "about extinct" in Applecross, and probably non-existent in the district as a resident species.

Falco islandus, *Gmel.* Iceland Falcon.

One killed at Inverbroom, May 1851 (Bond, *Zoologist*, 1851, p. 3275).

Falco peregrinus, *Tunstall.* Peregrine Falcon.

Resident, fairly abundant, and still holding its own, although certainly not free from persecution. Few of the mountains in the district that afford suitable nesting-sites are without a pair of peregrines.

Falco æsalon, *Tunstall.* Merlin.

Although the district affords many suitable haunts for the Merlin, this little falcon is far from common in Torridon and Applecross, though it is reported as fairly abundant in Fisherfield and Dundonnell. Its comparative absence in Applecross may be due to the scarcity of larks and other small birds on the moorlands of that region.

Falco tinnunculus, *Linn.* Common Kestrel.

The most abundant hawk of the district, breeding commonly in the rocky burn-sides and in the woodlands.

Phalacrocorax carbo (*Linn.*). Cormorant.

Fairly common in the sea-lochs, but has not a breeding station, to our knowledge, in the area.

Phalacrocorax graculus (*Linn.*). Shag.

Common along the coasts. Several breeding sites in Outer Loch Torridon.

Sula bassana (*Linn.*). GANNET.

Visits Loch Torridon in small numbers after the breeding-season. The nearest nesting-sites are Stack and Sula Sgeir, north of the Butt of Lewis.

Ardea cinerea, *Linn.* COMMON HERON.

Common everywhere along the shores. There are heronries on islands in several freshwater lochs in Dundonnell and Gairloch, and the birds also breed in small numbers on the islands in Outer Loch Torridon—Shieldaig Island usually holding two to three pairs. They are numerous in Applecross, where they nest in large numbers on the cliff-ledges above the sea.

Anser cinereus, *Meyer.* GREY-LAG GOOSE.

Occasionally seen on Loch Torridon in winter. Does not appear to breed anywhere in West Ross except on the islands in Loch Maree.

Anser albifrons (*Scopoli*). WHITE-FRONTED GOOSE.

One is said to have been killed at Kinlochewe, February 1893.

Bernicla brenta (*Pallas*). BRENT GOOSE.

A specimen of this goose was shot at the head of Loch Torridon in the winter of 1891.

Cygnus musicus, *Bechst.* WHOOPER.

Comes to Loch na Loin in Glen Shieldaig every winter, in flocks of from twelve to twenty birds. Also seen on Loch na Sheallag in Dundonnell during hard weather.

Anas boscas, *Linn.* MALLARD.

Common and resident; a pair or two breeding on most of the shallow weedy lochans amongst the hills, and on some of the larger lochs on the low ground.

Querquedula crecca (*Linn.*). TEAL.

Common as a breeding species, and perhaps more abundant than the Mallard. Found nesting among the heather near the margin of hill-lochs, at an elevation of considerably over 1000 feet.

Mareca penelope (*Linn.*). WIGEON.

In the summer not common, and only observed at the head of Loch Torridon. Common as a winter visitant to Applecross, and along the coasts of Dundonnell, etc.

Fuligula ferina (*Linn.*). POCHARD.

Fairly abundant in winter. Has been killed at the head of Loch Damph.

Fuligula marila (*Linn.*). SCAUP.

Winter visitant; tolerably numerous in Dundonnell.

Fuligula cristata (*Leach*). TUFTED DUCK.

Observed as a winter visitant in Dundonnell.

Clangula glaucion (*Linn.*). GOLDEN EYE.

Winter visitant; occurs also on migration. Not uncommon.

Somateria mollissima (*Linn.*). EIDER DUCK.

Is reported as occasionally seen in the vicinity of South Rona, an island off the coast of West Ross.

Œdemia nigra (*Linn.*). COMMON SCOTER.

Reported by W. Macdonald as common on Loch Torridon in winter, and also seen inland on Lochs Damph and Coultrie.

Mergus merganser, *Linn.* GOOSANDER.

Seen on Loch Torridon in winter and early spring, and breeds sparingly in Gairloch and Applecross. Reported as nesting on the Torridon river, at the head of Loch Damph, and near the margins of fresh-water lochs in Applecross.

Mergus serrator, *Linn.* RED-BREASTED MERGANSER.

Resident. Abundant and generally distributed; nesting on islands and on the margins both of sea- and fresh-water lochs. Quite the most common sea-duck of the district.

Mergus albellus, *Linn.* SMEW.

A pair, one of which was an old male, seen a few years ago by W. Macdonald on a small fresh-water loch on the north side of Loch Torridon.

Columba palumbus, *Linn.* RING DOVE.

Fairly abundant, and, as elsewhere in the Highlands, decidedly on the increase.

Columba livia, *Bonnat.* ROCK DOVE.

Common along the rocky shores of the sea-lochs and outer coast, a pair or two breeding in every suitable cave or crevice.

Columba œnas, *Linn.* STOCK DOVE.

The Rev. E. S. Marshall writes in the *Annals of Scot. Nat. Hist.*, 1894, p. 115, under the heading, "Stock Dove in West Ross": "It may therefore be worth while to record the fact that in late August or early September 1877 I shot a specimen close to the shooting lodge of Dorisduan, Kintail, West Ross, and frequently saw birds of this species while fishing the river Croe. I cannot, of course, speak with any confidence upon the question of their having bred thereabouts, or immigrated after the nesting season; but the comparatively early time of year, and the tolerable frequency of their occurrence, make it quite as likely as not that they had been resident through the summer."

Phasianus colchicus, *Linn.* PHEASANT.

Introduced in several localities in Dundonnell, Gairloch, and Applecross.

Perdix cinerea, *Latham.* PARTRIDGE.

Sparingly distributed where there is cultivated land, and said to be fairly numerous in Dundonnell.

Lagopus mutus (*Montin*). PTARMIGAN.

Common on most of the higher mountains. The nests that have come under our notice have been placed on the slopes some little way down from the summit ridge, and usually on the sunny side of the hill.

Lagopus scoticus (*Latham*). RED GROUSE.

Generally distributed, but varying much in numbers from year to year in different parts of the area. The general consensus of opinion seems to be that the grouse are decreasing in most districts, the reasons given being disease, wet seasons, and—in Applecross—the destruction of eggs and young by the rooks.

Tetrao tetrix, *Linn.* BLACK GAME.

Fairly numerous, and increasing in the woods around Loch Torridon. When wire fences were first put up at Shieldaig the black game were nearly all destroyed by flying against them; but this cause of destruction gradually ceased to operate as the birds became accustomed to the wires, and the numbers are now nearly at their former level. Reported as decreasing of late years in Dundonnell and Applecross.

Crex pratensis (*Bechst.*). LANDRAIL.

Summer visitant to the cultivated lowlands, where it is fairly abundant, but varying in numbers from year to year.

Gallinula chloropus (*Linn.*). MOOR-HEN.

Very local and few in number; may be regarded as a rare bird in Applecross.

Fulica atra, *Linn.* COMMON COOT.

Said to occur as a winter visitant to Applecross. Not known in Dundonnell.

Charadrius pluvialis, *Linn.* GOLDEN PLOVER.

Not common as a breeding species. Thinly scattered over the extensive moorlands of the Applecross district. Particularly scarce in 1892, and absent from former breeding grounds. Visits the low ground at the heads of the sea-lochs in winter.

Ægialitis hiaticula (*Linn.*). RINGED PLOVER.

Abundant, and nesting freely on the shingly shores of the bays and sea-lochs. Suitable localities being scanty, the birds are consequently local in occurrence.

Vanellus vulgaris, *Bechst.* LAPWING.

Thinly distributed, and very local in the breeding season. Entirely absent, or only represented by a single pair in places where they might be expected to breed in large numbers.

Strepsilas interpres (*Linn.*). TURNSTONE.

Common winter visitant to the shores. Small flocks observed at the head of Loch Torridon during the last week of May 1890.

Hœmatopus ostralegus, *Linn.* OYSTER-CATCHER.

Breeds in large numbers along the coast and on the islands, but does not appear to ascend any of the rivers of West Ross.

Scolopax rusticola, *Linn.* WOODCOCK.

Resident, and not uncommon as a breeding species. Nests regularly in the woods around Loch Torridon. Several may be seen on the wing at once any evening in May and June, flying to and fro over the tree-tops. During their evening flight the birds have two distinct notes, which they repeat alternately, the one a short, sharp *chit, chit;* the other a low guttural croak.

Gallinago coelestis (*Frenzel*). Common Snipe.

Rare as a breeding species in Applecross. Very few birds have come under our notice during the summer months, though there is much suitable nesting-ground.

Gallinago gallinula, *Linn.* Jack Snipe.

Winter visitant to Applecross, but reported as very rarely seen in Dundonnell.

Tringa alpina, *Linn.* Dunlin.

A few pairs seen at the head of Loch Torridon all the summer, and the bird may possibly breed in the vicinity. Abundant in autumn and winter on the shores of Fisherfield and Little Loch Broom.

Tringa striata, *Linn.* Purple Sandpiper.

Visits the shores in winter and on migration. A specimen received from Dornie, Kintail, in February 1892.

Machetes pugnax (*Linn.*). Ruff.

A Reeve, we are told, was obtained at Applecross in 1878 by the Hon. Mr Willoughby.

Totanus hypoleucus (*Linn.*). Common Sandpiper.

Summer visitant, very abundant, frequenting the margins of streams and both fresh- and salt-water lochs. Breeds on islands in Loch Torridon.

Totanus calidris (*Linn.*). Common Redshank.

Not common, and very local as a breeding species. Seen in flocks on the shores of Loch Torridon as early as the first week in July.

Totanus canescens (*Gmelin*). GREENSHANK.

Thinly distributed and local. Two or three pairs breed annually on the moorlands adjoining both lowland and hill lochs in Applecross. Reported as fairly numerous in Dundonnell.

Numenius arquata (*Linn.*). COMMON CURLEW.

Very local, and not common as a breeding species, and appears to be confined to the low-lying ground at the heads and along the shores of the lochs. Small flocks of non-breeding birds seen on the shores of Loch Torridon throughout the summer.

Sterna macrura, *Naum.* ARCTIC TERN.

Common summer visitant to the shores and islands of the sea-lochs. The small colony on the storm-beach at the head of Loch Torridon was reduced to three pairs in 1890, but increased to fifteen pairs in 1892. Breeds on most of the islands in Outer Loch Torridon, and on islets in fresh-water lochs in Gairloch.

[**Sterna fluviatilis**, *Naum.* COMMON TERN.

Has not yet been distinguished in this district, but most probably occurs, though more sparingly than *S. macrura.*]

Larus ridibundus, *Linn.* BLACK-HEADED GULL.

We have no information as to the breeding of this gull in the Applecross district, but a few yearly visit Loch Torridon after the nesting-season.

Larus canus, *Linn.* COMMON GULL.

The most abundant gull of the district. Breeds on islands in, and on the shores of, Outer Loch Torridon. There is also a colony of forty to fifty pairs on an islet in Loch Lundie, 750 feet above sea-level.

Larus argentatus, *Gmelin.* HERRING GULL.

Resident and fairly abundant. About thirty pairs breed on Eilean Mhòr, and there is a smaller colony on Inverbain Island, in Outer Loch Torridon.

Larus marinus, *Linn.* GREATER BLACK-BACKED GULL.

Not abundant as a breeding species. One or perhaps two pairs nest yearly on the islet in Loch Lundie mentioned above, and on other small fresh-water lochs in Applecross. Breeds on Eilean Mhòr in Loch Torridon.

Larus fuscus, *Linn.* LESSER BLACK-BACKED GULL.

Although fairly abundant during the breeding season on Loch Torridon, we have no definite information as to their nesting-sites; but it is not improbable that a few pairs nest on the islands in the loch, as well as in possible inland localities.

Rissa tridactyla (*Linn.*). KITTIWAKE.

Said to visit Loch Torridon after the breeding season. Has not come under our observation.

Procellaria pelagica, *Linn.* STORMY PETREL.

Rare. Said to visit Loch Torridon in winter before heavy weather, especially from W. and S.W.

Alca torda, *Linn.* RAZORBILL.

A considerable number of Razorbills, together with a few pairs of common Guillemots and Puffins, are found in Outer Loch Torridon during May and June, and it is not improbable that a few of each species may breed on the islands and shores of the loch, which afford suitable nesting-sites.

Uria troile (*Linn.*). COMMON GUILLEMOT.

Frequently seen in Loch Torridon. See remarks under Razorbill.

Uria grylle, *Linn.* BLACK GUILLEMOT.

A few pairs breed on Shieldaig Island, Eilean Mhòr, and probably on the other islands and shores of Loch Torridon.

Fratercula arctica (*Linn.*). PUFFIN.

Present in large numbers on Loch Torridon in July and August. These birds have probably come in from the Shiant Islands, where there is the largest "puffinery" in Britain. See also our remarks under Razorbill.

Colymbus glacialis, *Linn.* GREAT NORTHERN DIVER.

Winter and spring visitant. Rare.

Colymbus arcticus, *Linn.* BLACK-THROATED DIVER.

Breeds on several lochs in Gairloch, and at least one locality in Applecross.

Colymbus septentrionalis, *Linn.* RED-THROATED DIVER.

Thinly distributed throughout the district, and perhaps more abundant towards the south than *C. arcticus.* At least three pairs nesting in Applecross in 1892, in all cases on islets in small lochs.

Podicipes auritus (*Linn.*). SCLAVONIAN GREBE.

A fine specimen of this Grebe, just assuming summer plumage, killed by Donald Matheson at Shieldaig in March 1893, is now in the Museum of Science and Art, Edinburgh.

Podicipes fluviatilis (*Tunstall*). LITTLE GREBE.

Not common and local. Nested at Diabaig in 1891, and breeds on other lochs in the district.

REPTILIA.

Pelias berus (*Linn.*). ADDER.

Abundant in most suitable localities, though not very often seen.

Lacerta vivipara, *Jacq.* COMMON LIZARD.

Generally distributed, and abundant in all the moorland districts.

Anguis fragilis, *Linn.* SLOW WORM.

Fairly common, but local. Abundant at Shieldaig, where it is often seen lying on the roads.

AMPHIBIA.

Molge palmata (*Schn.*). PALMATED NEWT.

The only newt as yet recognised in the district. Found in Loch Coire nan Faradh, Applecross. Also observed in Strathcarron.

Bufo vulgaris, *Laur.* COMMON TOAD.

Common, and generally distributed. Most abundant in the wooded districts.

Rana temporaria, *Linn.* COMMON FROG.

Universally distributed, and found high up on the mountain sides.

XXXII. *On the Geographical Distribution of Tropical Diseases in Africa.* By R. W. FELKIN, M.D., F.R.S.E., F.R.G.S. [Plate XI.]

(Read 18th April 1894.)

The origin of this paper was a request from the committee of the African Ethnological Congress, at the World's Fair in Chicago, that I should lecture for them on "Disease and Medicine in Africa." In preparing that paper, I was desirous of illustrating the climatology of Africa and the distribution of disease on a map, and the one which accompanies this paper was the result of my endeavours.

Few maps have been published illustrating the geographical distribution of disease, and, in the one I have constructed, I have attempted a somewhat new departure. I have divided Africa into eight regions, each having approximately the same climatology, and in each of these zones I have introduced symbols to show what diseases are present. I have also endeavoured, by repeating the symbols, to show the prevalence or the importance of the disease. Where one symbol occurs, the disease it represents is present in the area; if two symbols are marked on the map, the disease is very prevalent; and where three symbols occur, the disease is exceedingly rife, or the mortality from it excessive. A mere glance at the map will show the amount of disease in any area, and the comparative salubrity or unhealthiness of a district is at once seen. This, I trust, will be useful, especially as the rush to Africa still continues, and extensive schemes of colonisation are in the air.

When the map I have prepared is compared with one showing altitude, the reason for the presence or absence of many diseases is at once understood.

After describing the climatology of the various regions into which I have divided Africa, and enumerating the diseases met with in each area, I have added a short description of the tropical diseases met with, adding some remarks upon their probable origin, their prevention, and treatment. This, I think, may be of some use to travellers and others visiting the continent.

Notwithstanding the progress which has been made in medicine, in climatology, and in economics, even now we know little or nothing as to the effects of climate upon the human organism. The subjects of acclimatisation, acclimation, and the survival of the fittest, are, it is true, touched upon by many authors, and it seems to be the idea of many that these problems are more or less settled. This, however, is not the case.

As a rule, authors writing on Anglo-Saxon extension proceed on the *à priori* assumption that the Anglo-Saxon race can live and thrive more or less all over the world; and again, they assume that wheresoever this race may dwell they will remain, morally and physically, as they previously existed in their original habitat. True, some wiser writers do recognise the patent fact that Europeans and individuals from the Northern States of America cannot compete with the coloured races in the Tropics. They allow that the supremacy of the whites in the Tropics is artificial, wherever it may obtain. There the white races only keep *en evidence* practically by constantly reinforcing their ranks through importation. Even if we examine into the condition which obtains in Barbadoes, where the British have their oldest and, possibly, their most healthy tropical possession, we find that a cycle of constant fresh importation has been going on to keep up the stock. It is true that "mean whites" may indeed be found there, but they are the degenerate representatives of the race. In the Southern States of America, good authorities tell us that the Negroes are, owing to their better adaptation to the climate, gradually, but surely, replacing the whites. Looking for a moment to New Zealand, which is, of course, not a tropical country, we find that, notwithstanding the fact that the population is constantly receiving fresh British blood, it differs in a marked degree from the parent stem, owing to the apparently inscrutable action of climate upon human beings. It is evident, even to superficial observers, that the New Zealanders are mentally different from the original stock, and there is, doubtless, also some amount of physical alteration which, were sufficient attention paid to the subject, would be found to be important.

It would be interesting, did opportunity allow, to indicate, with some attempt at detail, the causes which lead to these marked changes, which are noticeable in emigrants and their descendants, but one remark must suffice; the hard winters in the north render the people industrious, provident, and capable of great endurance, or in such a country as New Zealand life is less gloomy and anxious, and the people are more lively—brighter—in fact more mobile. When, however, the climate, like that of Africa, is enervating, emigrants from the north become lazy, indolent, to some extent emasculated. National character is, on the whole, undoubtedly changed. It will be seen in the sequel what conditions to a great extent produce this change in character, and in the Tropics a change in physical stamina, likewise. It will not be possible, however, for me to apply the facts I allude to in this connection. My scope is a more limited one, but I have thought it well to call attention to the subject because of its great importance.

Looked at in the light of modern geology, Africa is of great antiquity. The origin of the continent belongs, doubtless, to Archæan, Palæozoic, and early Mesozoic eras. In round numbers the continent has an area of 9,858,000 geographical square miles, its length is 4330 geographical miles, and its breadth about 5000 miles. It is situated between latitude 37° 20′ 40″ N. and latitude 34° 49′ 15″ S. The coast-line is remarkable; it is only some 17,700 miles in length. This is out of proportion to its vast area, and is due to the absence of bays, inlets, or estuaries. The configuration of the continent of Africa is peculiar. It may be described as possessing a coastal girdle, having a varying breadth of from 100 to 300 miles in width. This girdle bounds an enormous plateau, which slopes from the east towards the west, and in the main axis of which, running from S.W. to N.E., there is a range of mountains, broken, it is true, at intervals.

The main elevation of the continent is less than that of Europe or Asia; an oblique line drawn from Loanda to Suakim passes through a table-land varying in height from 3000 to 4000 feet. It is remarkable that the three great rivers—the Nile, the Congo, and the Zambesi—have their headwaters almost together, so low is the watershed; and the whole river system of Africa renders ready drainage impossible, and thus gives to it, on the whole, a water-logged character, especially in vast areas in the centre of the continent. It is noteworthy that there are six drainage areas in Africa, three inland — the Sahara Desert, the Kalahari Desert, and Eastern Abyssinia — and then the Atlantic Ocean, the Mediterranean Sea, and the Indian Ocean,—the drainage area towards the Atlantic Ocean, including as it does the river systems of the Niger and the Congo, being the greatest. With the exception of the Nile, whose discharge is only about one thirty-seventh of the rainfall of the river's basin, the African rivers have an abnormal volume of discharge, due to the situation of their mouths in the equatorial zone, and the excessive rainfall in their catchment basins.

The lakes of the African continent may be divided into three classes—those situated in the continental axis, namely, the Victoria, Albert and Albert Edward Nyanzas, Tanganyika, and Lake Nyassa, possessing fresh water, and having an oceanic outlet; secondly, Lakes Chad and Ngami, which lie in continental depressions, and vary greatly in size during the various seasons, whose water is more or less saline; and lastly, the lakes situated along the course of the great rivers, and which are simply enormous expansions of these, caused by the heavy rainfall in the Tropics. In Central Africa the highest mountains are Kenia and Kilimanjaro in the east, and Gambaragara and Ruwensori in the centre, having an average altitude of some 19,000 feet.

Our knowledge of the climatology of Africa, except in northern and southern districts, is very incomplete, and this is unfortunate, because an exact knowledge of the climatology of Central Africa would be of the utmost interest and importance to us in our present inquiry. It will, however, probably be of advantage, before dealing with the climatology of distinct areas, which must, of necessity, be treated separately, to give a summary of the general phenomena of the climate of the whole continent, so far as it is known.

The mean annual temperature of the continent of Africa is high. There is a strip of country upon the east coast from lat. 23° N. to lat. 23° S., where the mean annual temperature is over 80° F., and the same high temperature obtains in two other regions. One of these is towards the west of the Red Sea, bounded towards the north by Dongola, on the south by Lado on the Nile, on the west by about long. 25°, and on the east by Abyssinia and long. 36°. The other area is situated towards the west, bounded on the south by the coast-line between Sierra Leone and Lagos, on the west by long. 17° W., on the east by long. 18° to 20° E., on the north by a pyramidal line lowest on the west and east at lat. 16° N., and having its apex at lat. 28° N., long 0°. Apart from this, with the exception of Morocco, Algeria, Tripoli, and the Nile delta, an oblong area commencing in Abyssinia, and running down to the equator, Cape Colony, Matabeleland, Damaraland, and Angola, where the mean annual temperature is between 60° and 70° F., the remaining part of the continent has a mean annual temperature of from 75° to 80° F. From this it will be seen that, although along the northern, western, and southern coast-line the temperature is to some extent lowered by the proximity of the ocean, yet on the east the sea exerts no modifying effect, but practically increases the temperature 5° to 10° F.

With regard to the mean annual range of temperature in Africa, considerable variations exist. There is a district which may be roughly said to embrace nearly the whole of the Congo Free State, where the range is less than 5° annually, and in the Sahara we arrive at the other extreme, the range being there between 40° to 50°. Practically, from lat. 18° N. to 20° S., the annual range is from 10° to 20°. With regard to relative humidity, it is over 70 per cent. in about a third of the continent. The upper boundary of this area may be described as a line drawn from Cape Verd to Lado on the White Nile on the north, bounded by 32° E. long. in the east and lat. 15° S. in the south, and including, also, the coast belt from Cape Town to lat. 2° N. on the east coast. Apart from this, with the exception of Abyssinia, where the humidity is also over 70 per cent., it is considerably less.

The rainfall in Africa likewise varies greatly, it being under 5 inches in the Sahara and in the Kalahari Desert. It is over 100 inches at Sierra Leone and between Lagos and Gaboon. Over the remaining part of the continent it varies from 10 to 100 inches. Speaking generally, the annual rainfall may be estimated at from 50 to 60 inches. The rainfall at the equator is pretty evenly distributed throughout the whole year, but to the north of the equator, at about 15° lat., there are two well-marked rainy seasons.

With reference to winds, the trade winds are the most important. North of the equator the prevalent trade winds are from the north-east, south of it from the south-east, with an intervening belt of calms at the equator, and it is to these winds that the unequal distribution of the rainfall is to be attributed.

The heat, rainfall, and winds naturally affect the fertility of the country, and the whole area of Africa may be divided up as follows:—36·4 per cent. is occupied by deserts, 14·6 by steppes, 5·3 by scrub, 21·3 by savannahs, 21·8 by forests and cultivated land, and 6 per cent. by the large lakes. Therefore half the continent is occupied by deserts and steppes.

The typical zones of vegetation are—(1) the Mediterranean zone, having a vegetation similar to that of southern Europe, if somewhat more tropical; (2) the Sahara Desert zone, of which much might be cultivated, numerous oases certainly existing there; (3) the zone of tropical vegetation, more or less coincident with the areas of the highest mean annual temperature and heaviest rainfall; and lastly, the south-central and South African savannah zone. In general terms, the vegetation is richer as we proceed from the south to the north, and also from the west to the east.

It is unnecessary to refer in detail to the fauna of Africa. The mammalian fauna is exceptionally varied, the bird fauna meagre, the reptile fauna largely developed. Insect life is very abundant, and the tetze fly infests large parts of the country which are uncleared.

The population of Africa may be estimated at about 20 to a square mile. Boehm and Wagner estimate the population at 205 millions, Mr Ravenstein at 127 millions, with a rate of increase of 10 per cent. per decade.

The people of Northern Africa were probably in prehistoric times of the same ethnical stock as that of the people inhabiting Southern Europe. The Arabs of the Soudan are probably all descendants from the proto-Semitic stock. For the rest we have Negroes of various kinds, but all distinguished by projecting jaws, flat features, broad noses, woolly hair, shining skin, and pouting lips, and it is probable that they are all of one origin. We find also in Africa the Bushman and Tikki-Tikki or Akka dwarfs, all of whom I believe to be among the oldest primitive inhabitants of the continent.

In classifying the ethnographic distribution of a population, it is best to be guided by linguistic facts; but, as according to Cust there are no less than 438 languages and 153 dialects spoken in Africa, such a classification is for present purposes impossible, and therefore I adopt Miller's classification of distinct groups, as follows:—(1) The Semitic family, along the north coast of Africa and of Abyssinia; (2) the Hamitic family, who dwell mainly in the Sahara, Morocco, Algeria, Egypt, and in the Galla and Somali districts; (3) the Fulah and Nuba groups, who live in the western central and eastern Soudan; (4) the Negro groups, in the western and central Soudan, in Upper Guinea and the Upper Nile region; (5) the Bantu family, everywhere south of 4° N. lat., except in the Hottentot domain; (6) the Hottentot group, in the extreme south-western corner of Africa, from the Tropic of Capricorn to the Cape; (7) the Tikki-Tikkis and Akkas, living in scattered groups to the north of the equator.

A few sentences are necessary with regard to the general characteristics of these people, to show their possible predisposition to certain diseases, their immunity from others. The inhabitants of Africa have, on the whole, a well-developed muscular system. Mentally they are like children, easily amused and easily roused to passion. They possess innate capabilities of high education, but it is a mistake to suppose that the average Negro child can be educated up to the European standard. Till the age of fourteen he will probably distance a European child in almost all brain work, but after this age the light-skinned Caucasian shoots ahead of the dusky child of the Tropics. As a rule, at least three generations are necessary to develop the Negro to our mental standard. Owing to the climatological factors to which I have referred, the natives possess a lethargic constitution. Nature being so bountiful, they have no incentive to strenuous manual labour. But there is a marked difference between the inhabitants of the mountainous regions of the Tropics and those inhabiting the low-lying plains. For instance, the inhabitants of the northern and higher parts of Uzinza are far more strongly built and energetic than the Wazinza who inhabit the southern and lower parts of the country. Such, at any rate, was the opinion of Speke, and I have personally noticed the same characteristics north of the equator.

Again, the religion and customs of the inhabitants necessarily influence their susceptibility to disease, or their power of recovery after having been attacked by disease. There is a marked difference between the stolid, fatalistic, Mohammedan and the superstitious pagan. A difference also obtains in many districts owing to diet, partly influenced it is true by custom, but also by religion, and the vegetarians and mixed feeders are liable to definite varieties of disease.

Although it is a mistaken notion that insanity and nervous diseases do not obtain among the natives, yet they are undoubtedly less frequent in Africa than they are in temperate latitudes; and it is certain that civilisation, or, at any rate, contact with the whites, has a more or less deteriorating effect upon the native population.

It is now necessary to refer briefly to the subject of acclimatisation, and to endeavour to answer the question which is frequently put—Can Europeans become acclimatised in Tropical Africa?

My strong opinion is that it can only be possible if migration occurs step by step, and in estimating the possibilities of acclimatisation we must count by generations rather than by years. I believe, however, that our increased knowledge of climatology and hygiene renders the problem of acclimatisation easier than it was, and, given picked individuals and the careful selection of tropical areas in which to colonise, I see no reason why, with precautions, inhabitants of the temperate zone should not colonise even in Central Africa. In the selection of emigrants, great care should undoubtedly be taken, and all persons with a tendency to gout or rheumatism, diabetes or albuminuria, those with a nervous or alcoholic family history, or those suffering from either acquired or hereditary syphilis, should certainly be restrained from emigrating to Tropical Africa.

As I before indicated, environment definitely influences not only individuals but nations, and for this reason a marked difference obtains between the adaptability of residents in the northern and southern parts of a temperate zone for acclimatisation purposes. Individuals and nations are not only influenced by the climatology of their original residence, but also by their habits and customs and their psychical peculiarities. It has been found, as was pointed out long ago by Mr Ravenstein, that the peoples of Southern Europe, such as the Italians and southern Frenchmen, can withstand the climate of sub-tropical Africa better than can northern Europeans. "A steady stream of migration is in fact setting in in that direction. Germans and Belgians are pouring into France; Frenchmen are going to Algeria; the Arabs from the shores of the Mediterranean have found their way into the Soudan; whilst the Soudanese are pushing forward into Bantu Africa. A similar movement is going on in South Africa. The descendants of those Dutchmen who, a couple of hundred years ago, first settled at the Cape have made their way to the Transvaal; and European migration, favoured by geographical features, is being pushed even within the Tropics towards the Zambesi."

This agrees with my own opinion, that wholesale immediate acclimatisation for Europeans in Tropical Africa is entirely out of the question.

But it may be said, What about the high African tableland? What about the mountainous regions? As it is customary to speak of three climatological zones—the hot, the temperate, and the cold—between the equator and the poles, so in like manner we can say that in the Tropics there are three vertical zones of climate. (1) A zone extending up to a height of 3000 feet, having a mean annual temperature of from 72° F. to 83° F.—the hot zone; (2) a zone from 3000 to 12,000 feet, with a mean annual temperature of from 41° to 72° F.—the temperate zone; (3) a zone from 12,000 to 16,000 feet or above, with a mean annual temperature of from 30° to 41° F.—the cold zone. Each zone has peculiarities of its own with regard to the presence or absence of disease, and the higher the altitude of the region within certain limits, the more nearly it approaches the climate of Europe. As we proceed, however, north or south of the equator, the boundaries of those zones are found at gradually decreasing elevations, and therefore heat, atmospheric pressure, etc., vary at different latitudes.

The influence of these zones upon disease is, broadly speaking, as follows:—In the upper or cold zone there is a tendency to plethora; the disorders met with are of an inflammatory character, and the diseases of the respiratory and circulatory organs are far from uncommon. Malaria, yellow fever, cholera, phthisis, dysentery, and hepatitis are almost entirely absent. The absence of phthisis is probably due to the rarification of the atmosphere, the absence of yellow fever to the lower temperature, as well as on account of the distance from the sea.

Areas situated at these high altitudes are incomparably superior to the low-lying districts. As a rule they are entirely free from tropical endemic diseases, which, should they perchance be introduced, rarely spread. A marked difference is soon noticed in the appearance of individuals who, after a residence in low-lying tropical countries, go to the hills or elevated tablelands. Their vigour improves rapidly, they regain almost the healthy appearance they had in Europe, their digestion and the composition of their blood is improved, and a proper amount of exercise can be taken. "Hill diarrhœa" and rheumatism may sometimes affect them in these higher altitudes. The former may be due to either a faulty water-supply or a too rapid removal from the plains; the latter—as in India—to damp dwellings, or to the more marked vicissitudes of climate.

The middle zone is perhaps best divided into two, which we may compare with the temperate and sub-temperate zones, the cooler (higher) having a mean annual temperature of from 41° F. to 55° F., the warmer (lower) a mean annual temperature of from 55° to 73° F. In both these areas the seasons exert an influence, and therefore the presence and prevalence of disease fluctuate, the frequency of diseases of the respiratory and digestive organs, for example, rising and falling correspondingly; but throughout this region, as a whole, diseases specially frequent in the higher and lower zones are less virulent in character.

The lowest or hot zone is the typical tropical disease zone.

Here we meet with anæmia, malaria, diseases of the gastro-intestinal tract, hepatitis, dysentery, diarrhœa, beri-beri, dengue, yellow fever, etc. Various diseases, however, are not met with, such as typhus, plague, goitre and cretinism, and, for the most part, diseases of the kidneys. It is obvious that inhabitants of the temperate zone dwelling in this lowest or hot zone must be injuriously affected by the climate, and probably the greatest injurious effect they sustain is due to the heat and equable temperature, the tonic effects of the cold season being sorely missed, in consequence of which there is a gradual sinking of the vital energy. Moisture is the next injurious element, for dry heat is much less injurious to such emigrants than a hot moist atmosphere. The character of the soil exerts a not inconsiderable influence, low-lying clayey soil, soil rich in mould, and alluvial soil, acting injuriously; dry or sandy soil being less injurious. If the soil be marshy, temperature is lowered, and it is found that by draining the soil the temperature will be raised 2 or 3 degrees. The drier the soil the greater the heat during the day, the greater the cold by night, owing to the rapidity with which the soil cools by radiation. Vegetation also influences the salubrity of these regions, for where it is abundant the temperature will be more equal, the vegetation preventing the sun from heating the ground, and also preventing radiation during the night. Lakes also exert an influence, by preventing much variation between the temperature of day and night.

A good deal is written concerning the high rate of mortality in tropical regions, but in comparing the salubrity of areas in the temperate zone and in the tropics, it is often left out of mind that much of the salubrity of Europe is due to artificial causes—to the prevention of disease, to sanitary measures, to the care of the sick and infirm, and to the superior medical knowledge of our law and civilisation. This fact can be at once appreciated when we consider the state of health and rate of mortality in different European states; and when we find such marked contrasts as are presented in Great Britain and Russia for instance, we observe that locality alone does not cause the great difference, and that it is not climate alone which influences disease and mortality.

The general salubrity of any place may be ascertained from the death-rate; in fact it is the only criterion we have. A low death-rate—say 20 per thousand—indicates that the climate and sanitary surroundings must be good. If the death-rate be, say 60 per thousand, either climate or sanitation must be at fault. In speaking of a "bad" climate in Africa, it must not be forgotten that what is meant is that the climate is bad for emigrants from the temperate zone, not necessarily that it is bad for the natives. Take, for instance, the west coast of Africa. The climate is not on the whole fatal to natives, and their death-rate is not immoderately high, although the district goes by the name of "the white man's grave." There are, it is true, exceptional areas where even the mortality amongst natives is great, but so too in the temperate zone there are areas where, owing to faulty sanitation, overcrowding, and the like, a state of matters inimical to health, and inducing a high rate of mortality, is to be found. A few statistics, taken haphazard, will show what I mean. The death-rate in Edinburgh in 1887 was 19·8 per thousand; in Manchester in the same year, 28·7; in New York, 1878-80, 26·2; in Chicago, during the same period, 27·2; in St Louis, 19·3; in Calcutta, 31·1.

Very much may be done to render even the worst climate in Tropical Africa more salubrious, and the sanitary precautions, to which attention will be called in the sequel, will do a great deal to raise the health of the community. For instance, attention to the water-supply at Sierra Leone has had a very marked effect in lowering the death-rate; but when all is done, a permanent residence for inhabitants from the temperate zone is at present out of the question in the low-lying regions of Tropical Africa.

We must now briefly consider the effects which the African climate exerts upon emigrants from the temperate zone, and which are chiefly the results of heat and moisture. For a short time after the arrival of such an emigrant in

Tropical Africa his health remains good, in fact the heat seems to have a stimulating effect upon him. He does not suffer from the heat of the sun, and he forms a striking contrast to those emigrants who have resided in the same district for a considerable time. His work, be it mental or bodily, is performed with comparative ease. Soon, however, he begins to experience a marked change in the physical functions of his body. Its normal temperature is about 1° F. higher than it was in the temperate zone, his respirations are considerably below the normal number, his heart's action is increased in frequency, his digestive powers become weakened, his skin secretes far more freely and becomes somewhat swollen, his urine is lessened in quantity, and his nervous system is, to a greater or less extent, enfeebled. There is no doubt that very soon his mental and bodily powers become weakened, this being due to modified nutrition. He suffers from anæmia and from a slightly congested liver. The anæmia, if only slight, may be considered as prophylactic in character, and the congestion of the liver is only what might be expected on account of the increased work that that organ is compelled to perform. The resistance which an individual from the temperate zone can offer to these conditions depends on the height of the mean annual temperature, and also to some extent on its diurnal variation. If the temperature is high during the whole year, he is less able to withstand them than he would be were there marked differences in the temperature of the various seasons, or between that of night and day. This power of resistance may also be attained by a change of air at stated intervals to a place, either having a high altitude, or where marked variation in temperature occurs. The difficulty experienced in Africa at the present time is that comparatively few high altitude stations are known, and some considerable number of years must elapse before arrangements can be made to provide access to those areas where the emigrant, enervated by the heat and moisture, may seek the restoration provided by a residence at a high-level station.

A word in passing as to the influence of the African climate upon women. Practically, although women do not suffer so much as men from malarial fever, this is probably due to their not being so much exposed to its influence. Taking, however, all things into consideration, I have come to the conclusion that neither sex is more capable than the other of withstanding the climate. With regard to children, it may be said that the same condition obtains in Africa as in India. Apart from accidental diseases, children will do well for the first three or four years of life, but under existing circumstances they must then be sent to a temperate climate if they are to survive. Were they to remain in Tropical Africa, they would certainly degenerate mentally, morally, and physically.

I have now come to the end of my extremely rapid survey of the general facts which obtain in Africa with relation to the subject of my paper, and I now proceed to describe, solely from the point of view of health and disease, the various regions into which Africa may be divided, and to indicate the special tropical diseases which obtain in them. When, then, the area of the distribution of the diseases of Africa has been geographically defined, I shall proceed to briefly examine each tropical disease, the conditions under which it arises, and its prevention and treatment, *seriatim*.

For my present purpose I can divide the continent of Africa into eight distinct divisions, namely,—

I. Northern Africa, including Morocco, Algeria, Tunis, and Tripoli.
II. North-eastern Africa, including Egypt and Abyssinia.
III. Eastern Africa, including the Islands of Zanzibar and Pemba.
IV. West Coast of Africa.
V. North Central Africa, comprising the Sahara and the Soudan.
VI. South Central Africa, extending to about 18° S. latitude.
VII. South Africa.
VIII. The Islands of Madagascar, Mauritius, and The Seychelles.

I. NORTHERN AFRICA.

This part of Africa has its climate modified by its proximity to the Mediterranean and Atlantic, and also by the ranges of mountains running parallel to, though at some distance from, the coast. It naturally falls into various political divisions.

1. *Morocco* is a dry and healthy country. It has a moist and fairly equable climate. There are two seasons—September to May being the winter, in which the rainfall is about 30 inches, and the temperature varies from 50° F. to 65° F. The summer, almost rainless, has a temperature of 65° to 80° F. Throughout the whole year the daily variation of temperature is remarkably slight.

The diseases specially met with in Morocco are dysentery and diarrhœa, which are very prevalent along the coast; and leprosy, syphilis, and ophthalmia, which are very common throughout the whole country. Chronic rheumatism is prevalent, scrofula not uncommon, but respiratory diseases and the eruptive fevers, with the exception of small-pox, are rarely seen. Malaria, manifested by intermittent fever, only obtains in a slight degree. Epidemics of cholera have frequently visited this country, as also all the countries included in Northern Africa.

2. *Algeria.*—This country must be divided into two parts—the sea-coast district, called the Tell, and the elevated region beyond, extending to the summits of the mountains, which have an altitude of from 3000 to 8000 feet. The mean annual temperature is about 65° F., the mean diurnal variation 42° F., the nightly variation 36° F. The average relative humidity is about 45 per cent. The rainfall varies in different districts, but the average at the coast is about 900 mm. The rain commences late in October, and ends about the end of March, autumn and winter occurring within this period. Spring begins in the middle of March and ends in June; July, August, and September being the summer months. There is a greater amount of disease in Algeria than either in Morocco or in Tunis and Tripoli. The death-rate from typhoid fever is slightly over 11 per 1000, this

disease being extremely common, especially in the towns. Diphtheria and croup are also widely prevalent, being 15 per 1000; diarrhœa and gastro-intestinal disorders rather over 29 per 1000. Dysentery also is very prevalent, especially in the district of Oran, where it is said to be due to the special character of the water. Small-pox and measles are to be found in Algeria, and both acute and chronic bronchitis and pneumonia are very frequently met with. This is contrary to what one might have expected. With regard to phthisis, the death-rate is high, but this is only in the towns, and is caused by the number of phthisical patients sent to Algeria in the hope of cure. It is a great mistake for patients in whom phthisis has become well-developed to be sent to Algeria, for, although the climate is exceedingly good for those in whom the disease is either threatening or is in a very early stage, it is undoubtedly prejudicial to those in whom it has taken firm hold. Leprosy and oriental boil are extremely common, and so is hepatitis, both the acute and chronic varieties, and tropical abscess of the liver (especially in Oran). Syphilis and acute rheumatism do not occur nearly so frequently as in Morocco. Goitre is prevalent in the mountainous regions. Malaria is very prevalent in Algeria, although it is not so frequently met with as formerly, for sanitary science is beginning to make itself felt and to diminish its occurrence. It is not so frequently seen in the province of Algiers itself, as it is in those of Oran and Constantin, in which districts it is about twice as prevalent. The amount of fever is unequally distributed throughout the year; the maximum amount occurs in the autumn, the minimum between December and May. July and October appear to be the two months when fever is most prevalent. Undoubtedly the heavy rainfall from November to February diminishes the fever. On the whole the fevers are most prevalent in marshy areas with a sub-soil of clay, but, as Colin points out, there are localities infested by malarious fevers which are far from being marshy. But this forms one of the peculiarities with regard to malaria, and, as I shall point out elsewhere, is, I believe, due to the height of the ground-water. Probably the most malarious districts are Mitidja, Bona, the Plain of Eghris, Gigelle, the plains of Zig, Habra, Zeybouse, and of Shotts, also the district through which the Macta Canal passes, and the borders of the Fezara Lake.

3. *Tunis and Tripoli.*—These regions are for the most part deserts, having a mean annual temperature of about 70° F., and a mean annual variation of about 30° F. Diphtheria, dysentery, and diarrhœa are very prevalent, the two latter diseases being especially met with between July and October. Syphilis and acute and chronic rheumatism are also very common, but diseases of the lungs and liver exceedingly rare. Almost the whole of the district is malarious, with the exception perhaps of the area in which is situated the Lake of Bizerta, and also Porto Farina.

Summarising the information we possess with regard to Northern Africa, we find that malaria, dysentery, diarrhœa, leprosy, syphilis, and rheumatism are exceedingly frequent; but it seems only probable that, were extensive sanitary measures adopted in the various countries referred to, and especially drainage and a good water-supply provided, the district would be far from inimical to emigrants from the south of Europe, and the climate is decidedly favourable to persons suffering from incipient phthisis. Such individuals should, however, spend at least two winters and the intervening summer in North Africa, if they would gain any decided benefit from a sojourn there. It is not altogether easy to estimate the progress made by France in the colonisation of Northern Africa, but on the whole I believe that gradual acclimatisation is taking place, and that in time the country may be completely and successfully colonised by that nation; and doubtless Italians and Spanish would fare equally well.

II. NORTH-EASTERN AFRICA.

In this division of my subject there are various climatological areas to be considered—(1) The Delta; (2) the Valley of the Nile; (3) the Eastern Desert, including the coast of the Red Sea; and finally Abyssinia. Part of the country politically known as Egypt will be considered under the head of the Soudan.

1. *The Delta.*—This area is humid, but the annual rainfall is only about 7 inches. Northerly winds prevail. The mean annual temperature is about 69° F., and the diurnal variation slight.

2. *The Valley of the Nile.*—The climate in this district is very different. The country may be practically said to be rainless. At Cairo there are only four or five showers a year, and in Upper Egypt but one or two. The mean annual temperature at Cairo is about 72° F., but the variation between night and day is very great. At Cairo the temperature may be as high as 110° F., but in the winter it may fall to below 32° F. The marked feature in the Nile Valley is the inundation of the country by the Nile, which begins to rise about the middle of June, reaches its height at the beginning of October, when it commences to fall, and it must be remembered that in Upper Egypt the river forms the sole source of the water-supply to the country. There is probably no other country in the world where the population is so dependent upon a single river, and unfortunately the Nile is habitually polluted with all kinds of filth, which has a great effect on the health of Egypt, for during the summer months, when the Nile is low, the people practically imbibe a solution of filth. This faulty water-supply undoubtedly causes the tremendous mortality amongst the child population. Out of 1000 children born in Egypt, 496 die before the age of five years (H. R. Green). It would be quite possible, although the cost would be great, to improve the water-supply; there are no insuperable engineering difficulties to be encountered.

3. The *Eastern Desert* and the *Red Sea* coast are drier and hotter than the Nile Valley itself. This notwithstanding, the country is salubrious. The heat from January to April is almost insupportable, especially during the southern khamseen, which is a dry scorching wind.

With regard to the diseases prevalent in these regions, typhoid fever, relapsing fever, and dysentery are very prevalent throughout the whole country, and simple febriculas are frequently met with. Epidemics of cholera have often visited Egypt, but plague, which used to be endemic here, has not reappeared since 1844. Ophthalmia is extensively prevalent all over Egypt. It is said that about a fourth of the whole population of Egypt is affected by the *Anchylostomum duodenale*, which causes the Egyptian chlorosis. Round worms are also very common, and guinea-worms, introduced from the south, are not infrequently seen. There is also a specific affection of the urinary passages caused by the *Bilharzia hæmatobia*, the embryos of which infest the drinking water. Small-pox is epidemic; measles and scarlet fever are frequently seen, and so are hepatitis and tropical abscess of the liver. Phthisis is very rare, except among the Negro population, in which it is frequently met with. Rheumatism, on the other hand, is frequent, especially at Cairo. Scrofula affects the natives, leprosy is endemic, and syphilis very common. On the whole, the country I am describing is remarkably free from malaria, although the disease is present in the autumn. The greatest number of cases occurs at Suez, where the sub-soil water is very high. Suakim and Massowa are also said to be malarious, but, owing to the character of the fevers in these two places, it is doubtful if we are not dealing with dengue, or may be with an endemic form of influenza.

4. *Abyssinia.*—Abyssinia, which is situated between 7° 30′ and 15° 30′ N. lat., and between 35° and 40° E. long., has a mean altitude of about 7000 feet. It is an extensive tableland, from which mountains rise to a height of nearly 15,000 feet. The highlands are mostly covered with pasture or cultivation, forests being rare. The climate of the plains varies with altitude, a very large district being healthy and temperate, suited even to European colonisation. The mean annual temperature of the lowest part of Abyssinia is about 86° F., and the rainy season begins in December and ends usually in March. In the highlands the mean annual temperature varies from 67° to 55° F., according to altitude. The rainy season is from June to September, the rainfall being about 40 inches.

Diarrhœa, dysentery, and rheumatism are very prevalent in Abyssinia. Small-pox, for which, by the way, inoculation is employed, is exceedingly prevalent, as also is syphilis, and leprosy is fairly common. The people, too, suffer considerably from worms, this being due to their custom of eating raw meat. Probably phthisis hardly exists in Abyssinia, and diseases of the chest are on the whole infrequently met with. In the rainy season typhoid fever, relapsing fever, and epidemic influenza are common. The natives also suffer from scrofula and leprosy, which is especially prevalent in the mountains, and goitre is said to occur. Cholera has frequently visited the country. Malarial fevers occur in Abyssinia, but not to anything like the extent that they do in other parts of Africa. There are, however, a considerable number of places where malaria is endemic.

III. Eastern Africa.

I include in this division of my subject the country between Cape Guardafui and latitude 18° N., and the coast inland to about longitude 36° E.; also the island of Zanzibar, because it really belongs to the east coast of Africa, and the conditions which obtain there are practically those which are found on the coast.

In the northern part of this area, between 10° N. lat. and the equator, we find the Galla and Somali districts. Little is known of them from a climatological and medical point of view, but in all probability they have the same characteristics as those mentioned when referring to Abyssinia, and these regions are undoubtedly healthier than any on the east coast farther south, if we except the highlands between Kilimanjaro and Mount Kenia and Victoria Nyanza.

From the equator to Delagoa Bay there are two seasons—the dry season from June till October, the wet one from November till May, the greatest rainfall being from April to June. The amount of rainfall varies in different localities from 1500 to 2500 mm. The mean annual temperature is about 80° F. at Zanzibar. February is the hottest month, with a mean temperature of about 84° F.; July the coolest month, with a mean temperature of 77° F. The humidity is very marked.

The inland districts of the east coast region do not vary much from the conditions which obtain at the coast, though of course altitude makes itself felt in modifying those conditions somewhat. Thus, around Kilimanjaro the mean annual temperature may be said to be slightly higher than at Zanzibar, mainly about 85° F., but there is a somewhat greater range, and the nightly mean is probably about 66° F. Farther south in the Mpwapwa district, according to Pruen, the maximum daily temperature during the hot season varies from 80° to 90° F.; the minimum at nights is 65° F. During the cold season the daily maximum varies from 70° to 80° F., the lowest night temperature being 60° F. At Blantyre, still farther south, and at an altitude of 3000 feet, the mean annual temperature is 64° F. The hottest season is during October and November, when the mean temperature is about 75° F., the coolest season being June and July, with a temperature of about 60° F. The rainfall in these districts is the same as that upon the coast, the smallest precipitation being near Blantyre, with an average amount of 58 inches, and increasing to 200 inches in the north.

The east coast of Africa is undoubtedly very unhealthy, and on the coast, and with few exceptions in the interior, emigrants from the temperate zone cannot thrive. Practically, the Shiré highlands, the slopes of Kilimanjaro and the districts to the north-west of that mountain are the only two areas in which it is possible to think of white races colonising. The diseases which do not occur on the east coast are scarlet fever, phthisis, and goitre, nor is cancer met with. Whooping-cough is occasionally known; hepatitis and tropical abscesses of the liver are less frequently met with than might be expected; measles are very rare, although one or two serious epidemics have occurred in the southern part of the district under consideration. Both the anæsthetic and tubercular forms of leprosy are occasionally met with. Cholera has visited the east coast of Africa on several occasions (Christie). Rheumatism, especially the chronic form, is met with all over this area, and syphilis and ophthalmia are very prevalent. *Elephantiasis arabum* is also seen, but not extensively, except at Zanzibar, where it is very common. Tropical ulcers are very frequently seen; they occur chiefly in the debilitated natives, and cause great havoc in the slave caravans. Diarrhœa prevails extensively. Dysentery is extremely common throughout the whole of the area, especially at Zanzibar. Epidemics of dengue are of frequent occurrence. Although, as has been mentioned, phthisis is not met with in East Africa, yet pleurisy and bronchitis are very common. Typhoid fever is fairly common. Beri-beri also exists in East Africa, and it is probable that the epidemic dropsy which is mentioned by Livingstone was really this disease. Throughout all East Africa malarial fevers are very rife; they are most severe upon the coast, along the river valleys, and in marshy, water-logged areas; in fact they are met with wherever the factors known as those producing malaria exist. To these I shall refer subsequently when dealing with the prevention of the disease. It should be noted, however, that the fevers on the table-land are much less fatal in character than those met with upon the coast, and there are areas over 2500 feet in altitude, where it may be said that the incidence of malaria is of but slight import. It may be well to mention here that the reason why East Africa has such an evil repute owing to the many deaths which have occurred amongst the Europeans who have visited it, is due to the fact that these explorers and missionaries have been compelled to make a long stay on the coast before proceeding inland, and have there become saturated, as it were, with the malarial poison. Were these conditions rectified, and were it possible for the whites to proceed rapidly to the interior, there is no doubt that their general health would be far better, and it is for this reason that for the last ten years I have so strongly advocated the construction of short railways to carry travellers rapidly across the malarious belt on the coast.

IV. West Coast of Africa.

The west coast of Africa from Cape Verd to Cape Frio, is the hottest and wettest region in the globe, probably the most unhealthy too. The expression, "the white man's grave," which is given to this part of Africa, is well deserved. The conditions which are so inimical to the white races in this region are continuous heat, excessive moisture, and sudden changes of weather, but much may be done to render the climate more salubrious by sanitary precautions. On the whole coast probably the Cameroon mountain system is the only place of sufficient altitude to form a really valuable health resort, but the Portuguese coast is not so unhealthy as that farther north.

A rapid summary of the climatological conditions which obtain in the various regions along the west coast must now follow.

First, with regard to the coast of Senegambia. The mean annual temperature is 75° F.; the mean diurnal range 9° F. The average rainfall is about 18 inches; the average humidity 73. The hottest months are June to November. In the interior of the country the mean annual temperature is about 83° F., the hottest months being April to June. There is considerably more variation in the temperature in this inland region, it having an average for the year of 18° F. At Bathurst, which is situated on St Mary's Island, the chief rains fall from July to September, about 39 inches falling in 80 days. At Sierra Leone the mean annual temperature is 82° F.; the rainfall 100 inches in August and September. On the Gold Coast at Accra the mean annual temperature is 80° F.; the mean range about 7° F. Humidity is very high, averaging about 75 per cent. The rainfall varies considerably, some years being as low as 23 inches, in others nearly 40. The rainy season begins at the end of March and continues to June. The dry season is from November to March.

We may take the climate of Lagos, still farther to the east, as another example of the meteorology of Western Africa. The dry season obtains from the beginning of December to the middle of March; then follow the heavy rains until the middle of July; from then till September there is a moderate amount of rain until the end of November. There is however some rainfall during each month, but only about 1 inch from December to March.

The total rainfall is about 58 inches annually, and the mean annual temperature 80° F. The mean annual variation is very slight, being only about 10°.

The Niger district has almost the same characteristics as the one just mentioned, except that the temperature is somewhat higher, the heat during March to June or July averaging 105° F., the mean annual temperature being about 86° F. The rainfall is about 60 inches; the relative humidity about 85. Proceeding farther south, we come to Gaboon, where the mean annual temperature is 95° F., the rainfall from 100 to 110 inches, the relative humidity very high, rarely under 90. The heaviest rains occur between September and January.

The next district to be mentioned is that at the mouth of the Congo. The mean annual temperature is 76° F., the annual range 9° F.; the rainfall 43 inches; the relative humidity for the year 75 per cent., the annual range 13. The rainy season is from November to May, with prevailing westerly winds.

With regard to the next region, Angola, the following data represent the climate at St Paul de Loanda. The mean annual temperature 74° F., the annual range 12° F.; the rainfall 13 inches; the relative humidity 82 per cent., and the annual range of humidity 10. Here there are two rainy seasons—October to December, and March to May.

In the districts to the south, namely, Benguela and Mossamedes, the country is drier, the rainfall varying from 10 to 30 inches, the mean annual temperature being about 68° F. the annual range 20° F.

The disorders met with on the west coast of Africa, and which may be regarded as the most prevalent tropical diseases, are numerous, and we have to deal with two of them which are unknown on the eastern side of the continent, namely, yellow fever and yaws. Following the rough order which I have hitherto adopted, we find that typhoid fever is met with occasionally in Senegambia, more rarely perhaps in Sierra Leone. It is not reported from the Gold Coast, but it occurs in the Niger district, as also in Gaboon. There are no reports of typhoid fever from the Congo, but, as it is stated that typho-malarial fever occurs there, in all probability it does exist; for as I shall point out subsequently, I am convinced that typho-malarial fever does not exist as a disease *per se*, but that in all cases where typho-malarial fever is reported we are really dealing with patients in whom both typhoid fever and malaria are present.

Diarrhœa and dysentery are extremely common in Senegambia, being most frequently seen from September to November; also prevalent to a slightly less extent in December, January, and February. Both diseases occur also in endemic form in Sierra Leone; they are however not quite so frequently met with as elsewhere. Diarrhœa is often met with on the Gold Coast, but dysentery is more rarely seen, at any rate among the Europeans. Both diseases occur at Lagos, as also with extreme frequency in the Niger district. Diarrhœa is very common at Gaboon, but dysentery, although endemic, affects the natives chiefly. Probably the diminution of cases amongst the white residents is due to sanitary precautions. On the Congo coast diarrhœa prevails, as also dysentery, but this disease is not nearly so frequent as in the Upper Congo district, to which reference will be made later on. In Angola, diarrhœa is fairly common, but dysentery is more rarely seen, and when it occurs it is chiefly after the rains.

Severe epidemics of dengue occur in Senegambia, but curiously enough that is the only place on the west coast of Africa where this disease obtains. Cholera visited Senegambia in 1868, but has not been recorded as occurring elsewhere on the west coast of the continent, although we do find scattered notes referring to sporadic cholera on the northern part of the west seaboard. Now in 1893 cholera is again ravaging Senegambia.

Beri-beri is very prevalent in the Congo district near the coast, as also is a disease called the sleeping-sickness or negro lethargy, a disorder which has a rather wider distribution, namely from Senegambia to this district. It is at present a moot question whether these two diseases are identical. It is also thought by some that both diseases are really due to the *Anchylostoma duodenale*, and if so they would be identical with Egyptian chlorosis, which is undoubtedly due to the presence of that worm.

Yaws or frambœsia is very frequently met with on the west coast of Africa, from Senegambia on the north as far south as Angola.

The area of distribution of yellow fever is at present limited in Africa to the west coast from 19° N. to a point on the mainland opposite Fernando Po.

Hirsch gives the following chronological survey of yellow fever epidemics on the west coast of Africa from 1816:—

1816. Sierra Leone, Congo coast.
1823. Sierra Leone.
1825. Sierra Leone.
1829-30. Sierra Leone.
1830. Senegambia.
1837-39. Sierra Leone.
1837. Senegambia.
1845-47. Sierra Leone.
1852. Gold Coast.
1857. Gold Coast.
1858. Senegambia.
1859. Sierra Leone, Senegambia.
1860. Gambia and the Congo coast as far as Angola.
1862. Gambia and the Congo coast, Gold Coast, Benin coast.
1864. Sierra Leone.
1865. Sierra Leone, Congo coast.
1866. Sierra Leone, Senegambia.
1867. Senegambia.
1868. Sierra Leone, Senegambia.
1878. Sierra Leone (?), Senegambia.

Diphtheria and scarlet fever are unknown, but measles occurs from Senegambia to Angola. Diseases of the chest, such as bronchitis, pleurisy, and pneumonia, are met with all along the coast, but phthisis is extremely rare among the natives, although it is of course sometimes seen amongst the whites, who have in all probability contracted the disease before proceeding to the coast. Leprosy is frequently met with both in its anæsthetic and tubercular forms in the native population on the whole of the West African coast. Syphilis and rheumatism, especially the acute form, are also extremely prevalent.

Elephantiasis arabum also occurs with comparative frequency over the whole coast, being especially prevalent on the Gold Coast, where also ainhum is frequently seen.

Small-pox occurs everywhere, and very severe epidemics often spread with extremely fatal results amongst the native population. Very few cases of cancer are met with on the west coast of Africa, but tropical ulcers are extremely common.

With regard to hepatitis and tropical abscess of the liver, there is considerable variation in the occurrence of these diseases, both amongst white men and natives. For instance, hepatitis is extremely prevalent amongst the whites in Senegambia, but is not often seen amongst the natives. It is comparatively rare in the Niger district, but is more frequently met with on the Congo coast. On the whole, tropical abscess of the liver is less frequently seen than one would expect, and it would appear to be a sequel to severe attacks of dysentery. This statement, however, should be taken with caution, as if it is true it is very different from what usually obtains in India and other tropical countries. Whooping-cough is said to occur in Senegambia, but I have seen no account of it elsewhere.

Amongst the native population over the whole west coast of Africa, skin diseases are common. Insanity is not frequent, but tetanus often occurs, especially amongst children. Rickets are comparatively rarely seen.

Anæmia is invariably found in Europeans throughout the west coast of Africa, and is usually due to malaria; it may however be due simply to residence upon the coast. Guinea-worm is especially frequent between Senegambia and Cape Lopez. In Senegambia it is met with not only on the coast, but in the more elevated region which extends from Bakel to Galem, though the parasite does not infest the banks of the Casamance. The Sierra Leone coast is less extensively infected by the guinea-worm than the Grain Coast, Ivory Coast, Gold and Slave Coasts. It is met with throughout the Niger district, and also in Gaboon.

It is to be noticed that on these coasts various places, such as Cape Coast Castle, Elmina, Cormantia, and Accra, are especially affected, whereas the surrounding country very often is free from the parasite. I do not believe that there is any connection between guinea-worm and *Elephantiasis arabum.*

Amongst the natives, nervous diseases are rather frequently seen. Hemiplegia, paraplegia, epilepsy (especially in women), acute mania, and dementia are met with.

Throughout the whole coast endemic dropsy occurs, but here again, as I said before in referring to the east coast, I think this is a form of beri-beri. Ague-cake is very common, especially in Creoles. It is said, however, to be uncommon in Sierra Leone, and Gore attributes its rarity in that region to the ferruginous character of the soil. Goitre is not frequently seen on the west coast of Africa; there are, however, some reports of its occurrence in the Cameroon district.

The west coast of Africa presents four seasons, which generally begin and end as follows, allowing for latitude and local peculiarities. The summer season extends from February 15 to May 15, the rainy season from May 15 to August 31, the harvest season from September 1 to November 15, while the harmattan or cold season begins on November 15 and ends on February 15.

The summer is hotter than any of the other seasons, the heat being greatest in the region of the trade winds, and greater in Sierra Leone than on the Gold Coast and Bight of Benin. In addition to the prevailing winds, which vary from N. and N.E. in February to S. and S.W. in April, the Gambia region is subject to the simoon, a hot wind charged with fine sand which blows from the desert, destroying vegetation and causing much distress, especially in respiratory diseases. Whirlwinds are also prevalent during this season.

The rainy season is ushered in by a cloudy atmosphere and frequent tornadoes. The rain gradually increases till in July and August it descends in torrents, in many places inundating the country and washing away huts and bridges. In the Gambia region the commencement of the rains is marked by occasional dirt gales, a strong wind carrying the surface earth along with it. The actual rainfall varies in different places, and also in the same place from year to year. It is greatest during the night, and at the beginning and end of the season the fall is limited to the night time. In the rainy season sand-flies and mosquitoes are especially troublesome.

The harvest season or autumn is the most unhealthy part of the year in West Africa. The rains moderate, the swamps begin to dry, while the decomposing vegetable matter favours the spread of malaria. The heat, though not actually so great as in summer, is far more oppressive from the moisture of the atmosphere. The south-west monsoon is the prevailing wind, and at the end of the season the north-east monsoon, while beyond the region of the "trades" there are the usual land and sea breezes. At the termination of the harvest the electrical condition of the atmosphere is much disturbed, this being followed by the cessation of rain for some months.

The harmattan or cold season is so called from a wind of very peculiar character which occurs at this time. It is cold and extremely dry owing to its course from the east over the Sahara. On its approach, vegetation of every kind is shrivelled up, and the lips and eyes of those exposed to it suffer from its parching effect. It is accompanied by a thick fog and mist, composed of particles of fine sand of the desert. It only blows for a few days in the season, the prevailing wind being from the south-east. This is the dryest season of the year, and is generally healthy; vegetable matter being shrivelled instead of decomposing as during the autumn, does not favour the production of malaria.

The months of February, March, April, October, and November may be regarded as the hot season of West Africa. During this period the increased heat gives rise to certain physiological effects on the human body. The temperature rises to 100° F. or even 102° F., the pulse is accelerated, the respirations diminish in depth and frequency, the urine becomes concentrated, and activity of the skin is enormously increased.

Although in the summer season the heat is most intense, it is not so unhealthy as the autumn, when the heat is combined with moisture. (The month of October is specially unhealthy.) The heat at first causes an exaltation of general sensibility, but afterwards this gives way to marked depression.

Exposure, intemperance, bodily or mental depression, may result in ardent fever, with cerebral or hepatic complications. Dysentery and diarrhœa occur chiefly when the water-supply is impure from storage or contamination with decaying organic matter.

The chief diseases met with during the hot season are ophthalmia, dysentery, intermittent fever, rheumatism, leprosy, guinea-worm, and prickly heat.

The rainy season is far more unhealthy than the hot months, especially at its commencement, and to a less extent at its close. The temperature of the air falls at the beginning of the rains, producing a feeling of vigour after the intense heat; but the moist atmosphere, combined with the sun's rays, greatly increases the perspiration, and along with this there is relaxation of the muscular system, with cardiac debility and congestion of the internal organs. Should the rainfall be scanty, irregular, and alternating with hot weather, severe outbreaks of fever are to be expected from the formation of pools of stagnant water rich in organic matter. Dysentery and diarrhœa are also prevalent from the contamination of the water-supply; while in addition to the diseases mentioned above, diseases of the respiratory system are also met with.

It is likewise to be noted that though guinea-worm may occur at any season of the year, it seems to be more troublesome during the colder months. Elephantiasis and goitre also seem to commence more frequently in the cold season, though afterwards the seasonal influence on their progress is less marked.

The season of the harmattan is the most healthy part of the year, the drying action of the wind stopping the decomposition of vegetable matter, and thus the production of malaria. When it begins, patients suffering from malaria rapidly become convalescent, while other diseases are frequently benefited in like manner. The dry, cold air, while it braces up the body generally, reddens the skin and renders it dry and harsh. The nostrils and pharynx become dry, the lips chap, and the eyes may become inflamed. The sensible perspiration is almost arrested, and the activity of the kidneys is correspondingly increased. In the absence of free renal secretion, copious diarrhœa may ensue, and may persist in spite of treatment till the wind abates. The other diseases are chiefly the result of the internal congestion set up by the cold, congestion going on to sub-acute inflammation of the liver and spleen, hæmorrhages from mucous membranes, and abortion. Infants suffer severely from cold in the intervals between the harmattan. Slight attacks of fever unattended by prostration may occur; also rheumatic attacks, but these are arrested on the recurrence of the desert wind.

According to Horton, the harmattan has a decided effect upon small-pox; the pustules soon heal up, and the disease disappears. Persons vaccinated whilst the harmattan wind is blowing are not protected against small-pox, as the vaccine will not take.

I shall now deal generally with the incidence of malaria on the west coast of Africa. All I can do is to give a summary, which I hope may indicate with some attempt at accuracy, not only where the disease is prevalent, but where it is met with in its most grave forms.

Some amount of confusion obtains as to the distribution of the graver forms of malarial fever in West Africa. This is due to the fact that some observers hold bilious remittent fever, blackwater fever, endemic hæmaturia, and typho-malarial fever to be distinct diseases. I do not agree with this view, and in what follows it must be distinctly understood that I entertain the conviction that these so-called various diseases are simply malarial fever distinguished by some prominent symptom which has given the name to a variety of that fever, as indicated above. Believing as I do that malaria is a disease *sui generis*, caused by the hæmatozoon discovered by Laveran, I classify the results of its action on human beings as follows:—Intermittent fever of varying types—*i.e.*, quotidian, tertian, quartan ague; remittent malarial fever, including bilious remittent fever, blackwater fever, hæmoglobinuric fever, and endemic hæmaturia; pernicious malarial fevers, including the comatose and algid varieties; masked malaria, including brow ague and the various neuralgias connected with malaria, and finally malarial cachexia.

To the causes of malaria, and its production being favoured by local circumstances, or prevented in some cases, I shall not now allude, preferring to deal with such matters later on, when speaking of the prevention and cure of the disease.

Although, as before mentioned, the West African coast is called "the white man's grave," yet it is undoubtedly true that to a certain extent it is not malaria which causes, or perhaps one should say has caused, the very high death-rate of even 50 per cent. amongst the whites on the coast. In the past, at any rate, this death-rate has been due to the fact of diseased individuals proceeding to Africa, to want of knowledge of the precautions necessary for a residence there, and unfortunately, in many cases, to the wilful ignoring of prophylactic measures and of a well-ordered life.

In Senegambia malarial fever causes at least 40 per cent. of all the cases of disease. In some places the admissions into hospital from malarial fever rise as high as 70 to 80 per cent. The greater number of cases occurs during the rainy season, or between June and November, and chiefly, in all likelihood, at the commencement and at the end of the rains, and probably the pernicious and bilious and hæmaturic fevers happen chiefly during the rainy season, when the mean monthly temperature is highest. With regard to the hæmaturic fever, it probably occurs only under certain circumstances, namely, in debilitated individuals, after extreme strain or excess, or after a severe wetting following repeated attacks of ordinary intermittent fever. The bilious remittent fever may be considered as an acclimatising fever, occurring chiefly in newcomers.

Next, in Sierra Leone the amount of malaria is extreme. The type of fever is here very severe, a very fatal remittent type being most commonly met with in the whites. Again we find that here also it is during the rainy season that malaria is most virulent. On the Gold Coast the same conditions exist, and grave remittent fevers, with bilious and hæmaturic symptoms, are extremely common, as also are pernicious fevers.

Along the rest of the coast malaria is very virulent as far as Cape Lopez. Some idea of its prevalence will be gained by mentioning the death-rate from 1878 to 1888. Unfortunately, the cause of death is not stated in the reports, but malaria appears to have been the chief cause.

There are no means of ascertaining the number of Europeans in Gambia during the years in question, but I have reason to believe there were about 54. The average death-rate there was 10·10 per cent. At Lagos, from 1879 to 1888, there was an average of 110 European residents; and the average death-rate was 10 per cent. At Sierra Leone, the population during the same years was about 271, of whom 108 were a floating population, *i.e.*, belonging to ships in the harbour. The total deaths of the resident population were 44, of the floating population 31, giving a total number of deaths during the ten years of 75, being 42 per cent. On the Gold Coast during the same year there was an average of 66 Government officials. There were 34 deaths, the average death-rate being 51·43 per thousand. The non-official population was about 126, the number of deaths 106, the death-rate being 81·48 per thousand; or, taking the officials and non-officials together, the death-rate per thousand would be 68·08, the average European population being 192.

In the Niger district remittent fever is very virulent, and this district is remarkable for the prevalence of pernicious malarial fever. It is here also that we have most reported cases of so-called typho-malarial fever, the only other region where this complication seems to prevail being the Congo district; at Gaboon and in its near proximity malaria is most rife during the first three months of the year.

In the Congo coast region the average death-rate from malarial fever appears to be about 30 per cent. I shall refer to its prevalence in the upper regions of the Congo subsequently.

To the south of Loanda, where the fever is very rife, malaria decreases in intensity and importance as we proceed southward.

V. THE SAHARA AND SOUDAN.

This area, which includes the country as far south as 10° N. latitude, takes in the districts of Bornu, Wadai, Darfur, and Kordofan, and must be dismissed in a few lines, statistics being wanting with respect to it. On the whole the climate is intensely hot in summer, but the diurnal variation is very great. Sometimes the thermometer is many degrees below freezing point at night, although during the day it may be as much as 115° F. In the northern part of this district the mean annual variation or range of temperature is from 40° to 50°. In the southern part, in Wadai, Darfur, Kordofan, the range is considerably less, being only from 10° to 20° F. Over the greater part of the area the mean annual temperature is over 80° F., although in the district round Wadai it varies from 70° to 80°, this being due to the altitude of the country, which is from 3000 to 8000 feet. On the whole, this district may be said to be healthy. Except in the oases, malaria is almost absent. In Darfur and Kordofan dysentery, diarrhœa, and typhoid fever are met with; syphilis and bronchitis are fairly common; and in the southern part of Darfur the guinea-worm is very frequent, the area of its northern distribution at this point being about 11° N. lat. Goitre is not infrequently seen in inhabitants of the Djebel Marra. The most malarious parts of this district are the low swampy regions round Lake Chad, Dibbe, and Filter, and the province of Fezzan.

VI. EQUATORIAL CENTRAL AFRICA,

including the Congo Free State, and reaching south to the 18th degree of S. lat.

The mean annual temperature of the whole of this region is about 78° F., being slightly lower to the west of the Victoria Nyanza in the Ruwenzori mountain region, on the high plateau to the east of the Victoria Nyanza, and in Msiri's kingdom, where it varies from 65° to 70° F. The mean annual range of temperature in the Congo region is less than 5° F.; in the remaining area it is between 5° and 10° F., except in the region to the south of the Victoria

Nyanza, bounded between 32° and 38° E. long., where the mean variation is from 10° to 20° F. The mean annual rainfall is about 50 inches, except in the centre of this area, where it reaches about 100 inches, this including the Congo forest district and the country to the west of Tanganyika as far south as 10° S. lat. In this district also the relative humidity is over 70 per cent., but over the whole district the relative humidity may be taken as about 66 to 68 per cent.

The whole region is highly malarious, but I will give a brief account of malaria as I met with it in Central Africa. The area referred to extends from Khartoum in the north as far south as the Victoria and Albert Lakes, and also includes the Rohl and Bahr-el-Ghazel districts. The distribution of malaria in this region is unequal, and the topography of the country exerts an influence both upon its frequency and its severity. In low-lying swampy regions malaria is very common, the natives suffering to a considerable extent from mild attacks of intermittent fever. Occasionally one sees a case of well-marked remittent, but perhaps the most frequent variety met with is a form which at first sight appears to be a continued fever lasting from five to seven days. But when these fevers are examined carefully it is found that they are really either mild remittent (for there are distinct remissions, which, however, must be carefully looked for) or they are quotidian, with badly-marked paroxysms. A very brief cold stage occurs daily, then follow eighteen or twenty hours of hot stage with a temperature of 102°-103° F., followed by an hour or so of apyrexia after a very slight perspiration. Throughout the whole region the natives, who are fairly stationary in one district, suffer comparatively little, and from but slight attacks of intermittent fever, but if removed to a new locality they suffer from much more severe attacks, from remittent fever for the most part, and it is a noteworthy fact that after slave raiding or war numbers of men are struck down by severe forms of fever.

In the higher regions the fevers become more rare until one reaches districts having an altitude of from 3000 to 4000 feet, where they almost entirely disappear. A good example of this may be seen in the country to the north-west of the

Albert Nyanza, also in Central Unyoro, in the Shuli district, to the south-east of Dufli, and in Uganda, in the Kahura district.

With regard to the effect of malaria upon Europeans and Egyptians, one notices marked differences; and here the personal equation comes notably into play. Some suffer very little from malaria, others suffer from severe remittents and from what some call bilious remittents and black water fever. On the whole Europeans suffer less from anything more than an occasional attack of typical intermittent fever than do the Egyptians. Inactivity, severe marches in the sun or by moonlight, and fatigue, are the predisposing causes of attacks of fever in Europeans. In all the old Egyptian stations which I have visited, the Egyptian troops and officials suffered excessively from malaria. It was very fatal, or if not fatal, it induced such marked debility that they were greatly incapacitated for ordinary employment. I found that the "spleen test" was very useful in ascertaining approximately the salubrity of a district. The Bahr-el-Ghazel district is, owing to its very abundant water-supply and its many swampy areas, excessively malarious. The country to the north of the Bahr-el-Arab is comparatively exempt.

I pass on now to deal briefly with the subject of enteric fever. At Khartoum it is endemic, and no wonder, when one considers the filthy condition and want of all sanitary precautions in that town, and the quagmire into which it is yearly transformed at high Nile. After the inundation of the Nile the disease spreads all over the so-called island of Meroë. In all the districts I have mentioned above, as also in Kordofan, I met with cases of enteric fever, but they varied in frequency, not so much with the character of the country or the climatology, as with the habits and customs of the natives, and their sanitary surroundings. The disease was most frequently seen in the larger settlements in the Bahr-el-Ghazel districts. There, where the slave-dealers were in the habit of crowding together thousands of slaves, the filthy condition of the places can be well imagined, and it was in these hotbeds of disease that I saw most cases of enteric fever. Still, I met with the disease at Bohr on the White Nile, at Foweira, at Magungo, just to the north of the Albert Nyanza, and I witnessed one epidemic in Uganda. I say epidemic, because it was curious to notice that, generally speaking, enteric fever seemed to stop short directly an area was reached in which the banana forms the staple food of the population. It was far more frequently met with in those districts where the people lived chiefly upon grain.

I was surprised in my journey in Central Africa to notice the distribution of phthisis, for, although bronchitis, pleurisy, and pneumonia were constantly seen in nearly all the districts through which I passed, the cases of phthisis which I was able to observe were few and far between, and corresponded in a marked manner with the absence of malaria, at any rate in its most intense forms. From Khartoum along the valley of the Nile as far as the Albert Lake, through the swampy districts of Unyoro and Uganda, I can recall having seen very few cases of phthisis (in Uganda some eighteen or twenty). Subsequently, however, I saw a considerable number of cases in the Shuli district, at an altitude of 3000 to 4000 feet, where malaria is very rare. Again, in travelling through the Bahr-el-Ghazel district I saw a considerable number of phthisical individuals, not inhabitants of that province, but men or women, soldiers or slaves, who had come from the elevated districts in the Monbuttu country. Farther north, at Dara, I again met with phthisis in people who inhabited the highlands of the Djebel Marra district, where I was informed that malarial fevers were entirely absent.

With regard to the other diseases of Equatorial Africa, what follows refers to the districts mentioned above, and with which I am personally acquainted; but from what I have read on the subject, I have reason to believe that the same diseases obtain to the south.

Small-pox occurs in epidemics, and is very fatal. Measles and scarlet fever are unknown. Rheumatism is common everywhere, and cholera has on various occasions passed through the country in the form of epidemics. With regard to phthisis, it is very rarely met with throughout the whole of the northern part of this area, except in the high region to the north-east of the Victoria Nyanza, where it is more common. Diseases of the chest are found throughout the whole region, but bronchitis is far more common than either pleurisy or pneumonia. A form of plague has visited Uganda on several occasions, and there are reports of it having occurred on the White Nile to the south of Lado and in the Bahr-el-Ghazel district. Guinea-worm is most prevalent to the west of the Nile throughout the province of Rohl and Bahr-el-Ghazel. Round worms are also met with, and yaws is occasionally seen. Syphilis is widely spread in those districts where the slave trade has been carried on, but it is not prevalent in other regions. Leprosy is met with, but not extensively. *Elephantiasis arabum* occurs, especially on the west of the Nile to the south of Lado. Skin diseases are extremely frequent, except in Uganda, and boils are of common occurrence everywhere.

With regard to nervous diseases, temporary insanity is often met with, but it is rare to see cases of permanent aberration. Epilepsy is fairly common, and occurs chiefly in girls.

Ophthalmia is comparatively frequent, although it is not nearly so prevalent as in Egypt. With regard to diarrhœa and dysentery, both diseases are met with throughout this region. They are more prevalent throughout the Nile valley and in the west than in Uganda and Unyoro. The so-called blackwater fever certainly occurs, and so does typho-malarial fever, but in all cases I came to the conclusion that these were different varieties of remittent fever.

Passing now to the Congo region of Equatorial Africa, we find that malaria is prevalent over the whole of the district. All varieties occur, from mild attacks of intermittent fever lasting three days, to the most pernicious forms of fever, such as are seen at Vivi and Stanley Pool. It is said that the mortality of Europeans in the Central Congo region is about 25 per cent. Here, too, the so-called blackwater fever is common. There are no reports of enteric fever from the Congo, but typho-malarial fever is reported. I believe, however, that it is really simple severe remittent fever with typhoid symptoms. Dysentery is very common, and so is hepatitis, and tropical abscess of the liver is also met with. Phthisis would appear to be rarely seen, if at all. The ordinary diseases of the chest, however, occur; so do rheumatism and Egyptian chlorosis. Leprosy and yaws are both endemic in the Congo region, as also the disease of sleeping-sickness, as it is termed by writers from this region. As previously mentioned, I regard this disease as beri-beri.

We next come to the remaining part of Equatorial Africa, that to the south of the Victoria Nyanza, surrounding Lakes Tanganyika and Nyassa, as far south as the Matabele country. Throughout this region malaria is again extensively met with, except in the highest regions. Enteric fever exists to the south of the Victoria Nyanza, and it appears to occur occasionally as far south as the Zambesi. Both diarrhœa and dysentery are found, but dysentery is reported to be exceedingly severe throughout the whole district, far more frequent in fact than it is either to the north or west. Rheumatism, dengue, leprosy, and syphilis are all prevalent, and so are the ordinary respiratory diseases, but phthisis is extremely rare. *Elephantiasis arabum* is met with to the south-west of Tanganyika especially, but isolated cases are occasionally seen throughout the whole district. Tropical ulcers are seen very frequently in this district; so is ophthalmia, and probably beri-beri is widely distributed. Curiously enough, diseases of the liver and tropical abscess are rarely seen here. Diphtheria certainly exists, but it is not very prevalent.

VII. SOUTH AFRICA,

including the country south of 18° S. lat.

The area with which we have now to deal has a climate which differs much from any we have hitherto considered; it resembles more nearly that of the temperate zone, in which zone indeed the greater part of the district lies. The country varies considerably in altitude, lying generally from 600 to 10,000 feet above sea-level.

The mean annual temperature varies from 64° to 72° F., excepting in the Kalahari Desert, where it rises to about 76° F. The mean annual range of temperature varies somewhat: on the coast it is from 10° to 20°; inland it is from 20° to 40° F. The annual rainfall varies considerably. It is least on the west, where it is under 10 inches; indeed, in the north-west, it is only about 3 inches annually. On the eastern coast the precipitation is heavy, varying from 18 to 40 inches. Between these two areas, in the South African Republic and Orange Free States, the annual rainfall is from 10 to 25 inches.

In the most northern part of this area we have two districts—Mashonaland and Matabeleland. The altitude of this country is about 4000 feet. The rainy season is from November to February, and, on the whole, the district appears to be fairly healthy, although we have not sufficient reliable information upon which to offer a final opinion. We know, however, that dysentery, diarrhœa, and rheumatism are very prevalent, and that malaria also prevails, though, perhaps, not so extensively as it does to the north of the Zambesi.—Bechuanaland has the same elevation. In the west we have the Kalahari Desert, with a very slight rainfall and with considerable heat; but the eastern district is better known, and therefore, probably, we have information of more numerous diseases, although, on the whole, the country would appear to be healthy. The rainy season is from December to April; the average rainfall is 25 inches; the temperature may be as high as 85° or 90° F. The climate is, on the whole, dry and invigorating. Probably the most fatal disease in this district is dysentery. Enteric fever is also met with; malarial fevers are unimportant; measles and small-pox occur in epidemics; phthisis is unknown; bronchitis, pleurisy, and pneumonia are only very rarely seen. Syphilis is now common; rheumatism and hepatitis are both met with; ophthalmia is extremely common, and so is whooping-cough. Leprosy is not endemic; this is rather surprising, as the disease is prevalent at the Cape.

The Orange Free State is an elevated plateau lying 4000 to 5000 feet above sea-level. It possesses a remarkably dry climate, the humidity being about 55 per cent. During the six hottest months of the year the average maximum temperature is 82° F., the average minimum temperature 55° F. The dust-storms are the only drawback to this climate. The average maximum temperature for the six coldest months is 66° F. The rainfall is 16 inches. Diseases of the chest are very rare in this district, and it forms an admirable health resort for phthisical patients. Dysentery and diarrhœa are the chief diseases to be dreaded here.

The Transvaal has the same altitude as the Orange Free State, and possesses groups of mountains. It also has a dry climate, which is salubrious and exhilarating. The rainy season lasts from October to March, with an average rainfall of 30·74 inches. The principal diseases in this district are typhoid fever, dysentery, and diarrhœa. Leprosy and diphtheria are also met with; the occurrence of malaria is unimportant. Owing to sudden changes in the temperature, bronchial catarrh is fairly common. Phthisis is not seen.

In Natal, including Zululand, Basutoland, Griqualand East, and Pondoland, the climate in this region varies considerably. At Durban, on the coast, the mean annual temperature is 77° F., the mean range 18° F., the rainfall is 33 inches. At Pietermaritzburg and the interior, the mean annual temperature is 68° F., but the sudden changes from hot, dry land winds to moist sea breezes are trying. July to September are the most trying months in Natal. The rainfall at Pietermaritzburg is 31·87 inches. With the exception of isolated areas at the coast, and in some of the gullies in Zululand, malaria is practically unknown, but typhoid fever and dysentery are fairly common, as also is diarrhœa in the hot season. Respiratory diseases are very rare, but diphtheria, small-pox, measles, and scarlet fever sometimes occur in epidemics. Phthisis, except in imported cases, is practically unknown.

Cape Colony is, on the whole, very healthy. Temperature and rainfall vary in different places. At Cape Town itself the mean annual temperature is 67° F., the annual range

38° F., the rainfall 23·12 inches. At Port Elizabeth the rainfall is only 19·71 inches, and at King William's Town, 16·48 inches. At Graham's Town the air is bright and exhilarating; the mean annual temperature is 60° F., mean annual range 15° F., rainfall 22 inches, and, occurring as it does chiefly in summer, it keeps down the temperature and secures remarkable equilibrity. In this region malaria may be said to be absent. Again here, typhoid fever, dysentery, and diarrhœa are the most frequent and fatal diseases, and rheumatism, also, is very prevalent. Syphilis, leprosy, and scrofula are widely prevalent, but respiratory diseases are unimportant. Pneumonia, however, is more frequently seen in Cape Colony than it is farther north. Phthisis, owing to the number of imported cases, is more prevalent than one would expect, but apart from this, it is probable that the disease does exist in the Colony more than in other parts of the district we have just had under review. Scarlet fever, diphtheria, small-pox, and measles occur in epidemics, but infrequently. Heart disease appears to be specially prevalent. Cholera has never visited the Cape, and hydrophobia is unknown. Diseases of a parasitic nature are rare, and hydatids are infrequent.

VIII. African Islands.

Madagascar, the largest African island, is situated in the Indian Ocean, between 12° and 25° S. latitude. It can be divided into a low coast-line, and extensive highlands having an altitude of from 3000 to 4000 feet. The mean annual temperature of the coastal region is between 74° and 80° F.; the mean annual temperature of the highlands is 64° to 70° F., the mean variation between 5° and 10° F. The annual rainfall on the western half of Madagascar varies from 25 to 50 inches; on the eastern half it varies from 50 to 100 inches. At Nossi Bé, to the north-west of the island, it is over 100 inches. Malaria is most prevalent during the first three months of the year, and it prevails over practically the whole of the island. It is especially prevalent on the coast, and least so in the central provinces. Typhoid fever is also prevalent in the centre of the island; dysentery, on the other hand, occurs more frequently on the coast. Diarrhœa is met with all over the island; phthisis is said to occur in the higher regions, but, with the exception of pneumonia, diseases of the chest are comparatively rare. Rheumatism, leprosy, and syphilis are common. Beri-beri occurs in epidemics; diseases of the liver are fairly common.

The Seychelle Islands, situated between 3° 30′ and 5° 30′ S. latitude, are on the whole healthy. The mean annual temperature is about 77° F., the mean annual variation about 15° F., and the mean annual rainfall about 80 inches. Malaria is practically unknown, and diseases of the chest, with the exception of phthisis, are rare. The chief diseases of these islands are dysentery, phthisis, and affections of the liver. Leprosy and syphilis are fairly common.

Mauritius, an island lying between 20° and 20° 30′ S. latitude, is hilly, and has an elevation of from 500 to 700 feet. The mean annual temperature at St Louis is 78° F. April to November is the coolest part of the year. The rainfall is 70 inches. Up to the year 1866 the island was free from malaria, but since then it has been very malarious, both intermittent and remittent fevers being exceedingly frequent. The so-called bilious remittent fever is very common, and typhoid fever is also frequently met with. Dengue is epidemic; dysentery and diarrhœa are common, so are leprosy and syphilis; probably also beri-beri. *Elephantiasis arabum* is endemic. Chest affections are comparatively rare; but phthisis is sometimes seen. Ophthalmia is exceedingly prevalent, and hepatitis seems general amongst the white population.

The foregoing summary of the climatology of the various artificial regions into which I have divided Africa, and the account of the distribution of diseases occurring in them, has necessarily been somewhat dry and tedious; indeed, it has been very difficult to compress the necessary information within at all reasonable limits. I have now to give a general statement as to the nature of the prominent diseases met with in Africa, their cause and prevention, and the methods of treatment which are employed for their cure. It would of course require a volume to deal with the subject adequately, but I hope I shall be able to say sufficient to give an intelligent outline of the subject.

It will be well in the first place to describe what methods are employed by the natives in Africa in combatting disease, in so far as any obtain, and then to describe the methods of treating disease which are indicated by modern medicine.

It would be a hopeless task were I to attempt to describe in detail the minutiæ of medical and surgical treatment adopted by the natives for accident and disease in various parts of Africa, nor do I consider it necessary. It will be better, I fancy, to give a more general outline of the subject, but it is very necessary to state that I am doing so, for different methods obtain among different tribes, and even neighbouring tribes may have different ideas and customs with regard to any single disease. Were I not to state this definitely, I should easily lay myself open to criticism by any observer who had a knowledge of one single tribe exclusively.

The natives of Africa, and by these I mean the Negroes, Bantus, and the Arabs inhabiting the Soudan, excluding the Egyptians and the inhabitants along the northern African coast, have many superstitions with regard to medicine. Broadly speaking, one may say that the questions of life and death, health, and sickness, or accident, bulk largely in their ethical cogitations, and I do not think I am going too far when I say that the natives consider that all the evils which flesh is heir to result from the malign influence of the powers of the air. So they have pictured to themselves gods of small-pox or famine, gods of thunder, in fact a hierarchy of spirits who shape the destinies of men, and who may torment them if not controlled by charms or propitiated by votive offerings. Recognising this fact, remembering the native suspicious nature, their belief in fetishes and charms, the evil eye, etc., it is not to be wondered at that incantations play a marked rôle in their treatment of disease; but it is a mistaken notion to suppose that there is not a basis of true common sense underlying the hocus-pocus of which one hears so much in travellers' tales. The natives are observant; they recognise the fact that such diseases as small-pox and syphilis are contagious, and they attempt with varying success to prevent their spread. In many districts in Africa a rigid system of isolation is practised with regard to small-pox. The patients are treated in a hut set apart for the purpose, they are attended only by those who have previously suffered from the disease; a definite dietary is prescribed for them, simples are administered, the pustules are pricked with a sharp thorn, and thereafter various unguents, famed for their healing properties, are applied to the patient. In one district, at any rate, in Africa, inoculation is practised with the syphilitic virus, and neither young man nor maid there may marry until they have been through the inoculation ceremonies. The African natives have a considerable knowledge of the virtues of plants. Sudorifics, diuretics, febrifuges, purgatives, and emetics are known. Numerous barks and plants are selected as possessing these various properties, and, accompanied by incantations, are applied with no little success. The actual cautery and cupping are well-recognised procedures, and are employed in many diseases.

With regard to surgical operations, amputations are practised in some parts, but in many the patients would sooner die than suffer mutilation. Splints for the treatment of fractures are known and widely utilised; hæmorrhage is stayed in various ways, either by cautery, by the application of boiling oil or water, or of compresses composed either of astringent herbs, coffee grounds (in the Soudan), or cobwebs. It is when dealing with such diseases as epilepsy, insanity, or nervous disorders, that the natives completely fail, and where incantations pure and simple are resorted to. In dealing with labours, considerable ingenuity is often manifested; turning is sometimes practised; the child may be expressed, so may a retained placenta; in difficult labours positional treatment is in vogue in many places, and in some, even abdominal section is practised with more or less success.

As is well known, poisons and their antidotes find a not unimportant place in the medicinal lore of Africa. At least one of their poisons—strophanthus—is now a well-recognised medicine for heart disease, which has been adopted all over the civilised world.

What medical and surgical knowledge the natives possess is, as has been indicated, bound up with witchcraft, and the knowledge is usually handed down in families; or in some cases, as for instance in regard to poisons, it is regarded as a tribal secret, and the method of preparation of poisons and their antidotes is only communicated to such as, after initiation, have proved themselves worthy to be the recipients of that knowledge.

Such then in brief is the character of the native methods of treating disease. It now remains for me to indicate what light European medicine throws upon the treatment of disease in Africa, and how far modern medicine can either prevent, diminish, or cure the numerous maladies to which white races, as has been seen, are liable when transplanted to this foreign soil.

Certain characteristics should be possessed by individuals who leave a temperate climate to reside in Tropical Africa. First with regard to temperament. As was pointed out by Dr Moore, the *sanguine* temperament is associated with a tendency to congestive affections, to a rapid and irregular development of disease, to head affections, abscess of the liver, and scurvy.

Persons possessing this temperament are characterised by active muscular systems, and high animal courage, but they live at high pressure, and cannot sustain slight exposure to noxious surrounding influences. The *nervous* temperament is very sensitive, but there is much energy and capacity for endurance of fatigue, privation, and exposure; persons, however, possessing this nervous temperament, are prone to diseases of the nervous system and hepatic affections. With regard to the *bilious* temperament, the frame is powerful and the person possesses great endurance. He has the least sensibility of all to morbid disturbances and external impressions. He has no extraordinary tendency to liver affections, except in the extreme form, the melancholic bilious temperament. "The bilious temperament possesses the good qualities of the nervous, without its irritability, and of the sanguine, without its susceptibility to external impressions." Individuals possessing the *lymphatic* temperament do not resist disease well, and readily suffer from disease of the liver and derangements of digestion. It follows, therefore, that the bilious, or bilio-nervous temperaments are best fitted for residence in the Tropics; then persons of the sanguine temperament, but those would only stand the climate for a short time. Persons having a lymphatic temperament should stop at home. No one possessing a syphilitic, rheumatic, scorbutic, or malarious history should go to the Tropics, and persons either suffering from or having a tendency to heart disease should remain at home. With regard to age, no one should go to Africa under the age of twenty-five. Persons under this age are bound to suffer more from typhoid fever, from the severer forms of malarial fever, and from dysentery, than those who are older. With regard to women, apart from what has just been said, no woman with any tendency to the diseases special to her sex should go to the Tropics. With regard to phthisis, persons who have only incipient phthisis will do well in North and South Africa, and I am not at all sure that that disease should be a bar to their proceeding to Tropical Africa, provided that they are not going thither with the object of undergoing great physical exertion.

In going to Africa for the first time, it is well to arrive in the country in the coolest season. That season, as has been seen, varies considerably in different parts of the continent.

It is not my intention to refer to the diseases which, though occurring in Africa, are common to countries in the temperate zone. The outstanding diseases to which attention must be directed are yellow fever, malaria, dysentery, diarrhœa, and typhoid fever. With the exception of yellow fever, all these may be said to be prevalent throughout the continent. I will proceed to deal with the less important diseases first.

Ainhum.

This is a peculiar disease affecting the Negro race of both sexes. It always occurs in the small toes of the feet, and is diagnosed from leprosy and elephantiasis by there being no constitutional disturbance. The origin of the disease is unknown; it commences by an almost semicircular furrow in the digito-plantar fold on the internal and inferior surface of the root of the little toe. There is no marked inflammation or ulceration. The toe, however, increases in bulk until it is four or five times its ordinary size. The furrow gradually deepens until the toe hangs by a small pedicle to the foot. Sensibility of the toe is not lost. The treatment of the disease consists in amputation, after which it is not found that the other toes become affected.

Beri-Beri.

Beri-beri is a disease which manifests itself in anæmic or debilitated individuals; also in those following sedentary occupations. It is never met with in people until they have resided in the country, where it is endemic, for about a year. It is a fatal disease, death taking place either by syncope or from embolism. Its cause is unknown; there are, however, two theories in regard to it. The one is, that it is due to water impregnated by saline material, and the other that it is akin to Egyptian chlorosis (*q.v.*), and that water conveys to the individual the larvæ of the *Anchylostomum duodenale.* I incline to the former theory.

It has long been thought that a specific micro-organism must cause beri-beri, and two observers—Drs Mosso and Morelli—have examined the blood of eleven patients suffering from the disease, with uniform results. When rabbits and guinea-pigs were inoculated with cultures made from the micro-organisms of the blood, the animals apparently died from beri-beri, and after death three prominent conditions were found—ascites, hydroperi cardium, and nephritis. The liquid found in the abdomen and pericardium was strongly albuminous, and contained salts—corresponding, therefore, in general characteristics with the fluids found in the bodies of human beings suffering from beri-beri.

The symptoms are extreme weakness and prostration, dyspnœa and palpitation on exertion, numbness of the lower extremities, followed by œdema, anæsthesia, and, more rarely, by paralysis. The œdema gradually pervades the whole body, and effusions take place within the cranium, pleura, or pericardium. *Pari passu* with the increase of the dropsy, the whole body becomes numb. The urine is high-coloured and scanty, the specific gravity 1030 to 1040, and acid. It may be suppressed. Constipation is usually present. Considerable pain is often experienced in the cardiac region, and the pulse is irregular, unless effusion takes place within the cranium, when headache and delirium are frequent, and the pulse is slow and full. The prognosis is good if the disease occurs in young and otherwise healthy individuals, but the mortality on the whole is about 30 per cent.

The treatment consists in the use of iron, nux vomica and diuretics, and a stimulating nutritious diet. In India, Treeak farook is used with advantage. Frictions with rubefacient liniments are useful; petroleum, externally and internally, has been advised by S. Arokeum. The only preventive measure which can be recommended, apart from the ordinary precautions, is to ensure a good water-supply.

Bilharzia Hæmaturia.

This disease is caused by the ingestion of water containing the embryos of the *Bilharzia hæmatobia*, or possibly by bathing in water infested by them. It causes hæmaturia, cystitis, pyelitis, and sometimes dysentery. It is chiefly met with in Egypt and at the Cape of Good Hope.

It is quite possible that some minute leech-like animal fixes itself on the skin of the bather, and by means of an ovipositor implants the ova in some superficial cutaneous vein, and then the free embryos might be carried by the circulation from the ankle or leg to the pelvis. Persons who use river water, or water from pools or marshes, are most frequently attacked by the disease, those who use stored rain or well water being rarely affected. On examining the urine in these cases, it will be found to deposit a layer of dirtyish white flocculent matter containing short filaments of 135th of an inch in diameter, of a brownish colour and soft consistence. Microscopically, pus corpuscles are seen, and filamentous bodies containing great numbers of bright, highly refractive bodies imbedded in them. These bodies are the ova of the bilharzia. Stone in the bladder is not infrequently caused by the ova; the ova in the bladder become imbedded in a plug of hard mucus, and so form the nucleus of a stone.

Prophylactic Treatment.—After bathing in districts where this disease prevails, the skin should be thoroughly and very vigorously rubbed with a very rough towel. Filter and boil all drinking water. All raw salads and molluscous animals ought to be excluded from the diet. It is also essential to remove persons from the locality in which it is believed they have contracted the disease.

Treatment.—The patient must be well fed, must take moderate exercise, use cold baths and take tonics, either the mineral acids or the citrate of iron and quinine. Vesicle irritation must be subdued by the use of bicarbonate of potash and infusion of buchu. Hæmorrhage may be checked by uva ursi combined with small quantities of hyoscyamus, or hamamelis is very useful. Sometimes the injection of iodide of potassium, 3 to 5 grains to the ounce of water—and retention in the bladder for three hours—is beneficial. If the kidneys are affected, quassia, or the extract of male fern, should be administered. It is possible also that the following prescription may be given three times a day with advantage,—

R. Bicarbonate of soda, 15 grs.
Chian turpentine, 10 grs.
Acacia mixture, 2 drs.
Chloroform water to 1 oz.

to which opium may be added if there is much pain or irritation in the urinary passages.

Delhi Boil, or Oriental Sore, or Biskra Button, or African Date-Mark.

This disease begins by itching, usually of some surface on the exposed part of the body. A papule is then formed, which soon becomes pustular. The discharge from the pustule forms crusts, under which ulceration goes on. The sore lasts for about five or six months, leaving deep dark cicatrices, hence the name date-mark. It is inoculable, and occurs at all ages. It is not accompanied by pain or fever. It is usually single, but may appear in crops. Although it is certainly a specific affection, it is as yet impossible to determine its cause. It does not appear to be due to water, or to climate, or to eating fresh dates. Some believe (Carter) it is due to a mycelium arranged in open and angular meshes with conidia on its free ends, having subsequently bright orange-tinted particles arranged in spherical or ovoid groups, supposed to be a further stage of development. It is met with in horses and dogs.

Preventive Treatment.—The use of pure filtered water, good food, absolute cleanliness of house, clothes, and person, avoidance of overcrowding, and contact with the disease in animals or human beings, with careful attention to sanitary surroundings, are the only means which can be suggested as prophylactic to the disease. The local treatment should be water-dressings, followed by linseed-meal or bread poultices; but when the ulcer is formed, a stringent lotion, such as sulphate of iron, carbolic acid, and iodine may be applied. If the patient suffer from malaria, quinine must be given. If a scorbutic taint is suspected, fresh vegetables and lime juice, or fresh lemon juice are advisable; or should a syphilitic taint be made out, small doses of mercury and iodide of potassium will be advisable. In all cases a tonic regimen should be followed. Change of air and of drinking water is most desirable, and a voyage home may be needful in obstinate cases.

Dengue.

Dengue may be described as a specific fever, characterised by a high temperature, a peculiar and distinctive rash, violent and acute pains in the head and eyes, the muscles and joints; there is swelling of the joints, and the pains are apt to shift suddenly from one limb or joint to another; the throat and mouth are often affected, as well as the sub-maxillary glands; the sensorium is often much disturbed, and active, violent delirium is not uncommon. The disease is very infectious, and attacks persons of every age and sex. It may remit, and is liable to relapse. Some authorities consider that dengue is intimately connected with relapsing fever. Dr Christie thought that it was related to cholera. Although the complications of dengue are very troublesome, yet the prognosis is favourable. Deaths usually occur from syncope in children, in the aged, and in the debilitated. Summer and early autumn are the seasons when dengue is most prevalent. All epidemics have occurred during the hottest weather. It does not appear that the amount of moisture in the air has anything to do with its production. The onset of the disease is sudden. After suffering from severe rigors, the patient's temperature runs up to 103° or 104° F. Headache, pains in the joints, and nausea are prominent symptoms. The patient is sleepless and restless. Enlargement of the lymphatic glands is noticed. There may be epistasis, salivation, diarrhœa, or dysentery. Hepatic derangements are sometimes seen. Women may suffer from uterine hæmorrhage, and if pregnant are liable to miscarry. The first eruption, which appears on the third day, resembles that of scarlet fever, the throat being likewise affected. After two or three days the fever subsides, and the rash disappears, but after an interval of from 24 to 36 hours the fever returns, accompanied by a secondary rash resembling measles.

With regard to prophylactic treatment, no drug is of any service, but overcrowding and faulty sanitation appear to favour the spread of the disease. The greatest care should be taken in thoroughly disinfecting all fomites, for contagion may persist a long time, and the dead should be carefully disposed of.

General Treatment.—Castor-oil, or some warm carminative aperient should be given at the onset of the disease, violent purgatives being contra-indicated. Then the following effervescing draught is useful,—

℞. Bicarbonate of potash, 2 drs.
Tinct. opium, ½ dr.
Syrup of orange, 6 drs.
Camphor water to 6 ozs.

Half an ounce, with a tablespoonful of lime juice administered whilst efferverscing, every three or four hours.

For the restlessness, 20 or 30 drops of chloric ether may be given with each dose, or saline, such as acetate of ammonia, or citrate of potash, with nitrous ether, may be useful during the pyrexia. If the temperature rises above 105° F., the patient should be sponged with cold water. If the pain is very severe, 10 or 15 drops of the tincture of belladonna should be given every three or four hours. Opium or chloral, or Dover's powder in moderate doses, are sometimes useful at bedtime. The eruption should be treated with simple bismuth ointment. Warm baths, in which a couple of pounds of bicarbonate of soda have been dissolved, are also beneficial. Liniments containing opium, belladonna, and chloroform may be applied to the spine and joints. After the first remission the following prescription should be given,—

℞. Carbonate of potash, 1 dr.
Nitrate of potash, 1 dr.
Tincture of orange, 3 drs.
Water to 6 ozs.

1 oz. every three hours, and quinine 5 to 8 grs. should be administered thrice daily. For convulsions in children, bromide of potassium may be given. In adults, if there be great depression or marked nervous symptoms during convalescence, dilute phosphoric acid with nux vomica, or small doses of strychnine, should be employed. The enlarged lymphatic glands may give trouble during convalescence; they should be painted with strong iodine paint, and small doses of iodide of potassium should be given internally. The rheumatic pains are apt to persist, and it may be necessary

to blister the surface, and dress the blister with morphia; and if the internal administration of belladonna does not succeed in controlling the pain, the following prescription should be tried,—

℞. Nitrate of potash, 40 grs.
Spirits of sweet nitre, 2 drs.
Colchicum wine, 2 drs.
Water to 8 ozs.

1 oz. thrice daily.

Guinea-Worm.

(*Filaria Medinensis; Dracunculus Medinensis.*)

The guinea-worm is a nematoid worm, the female only of which is known. It is about 1 mm. thick, and has an average of 2 feet in length; it may, however, be much longer. It is cylindrical; the anterior extremity is rounded, and presents a small depression surrounded by an elliptical chitinous plate, at the margin of which are two papillæ. The posterior end is a short curved point; it is opaque, of a milk-white colour, and on each side there is a longitudinal line. The interior of the worm contains an immense number of young filaria in an acrid secretion. The tenacity of the tissue of the guinea-worm is considerable, so that a loop of the parasite will support the weight of 10 oz.

The largest number of persons becomes infested with this worm at the end of the rainy season, or in the hot season afterwards. The guinea-worm attacks all races and nationalities, both sexes, and at all periods of life. Usually only one or two worms are found in the patient, but I once saw one with no less than forty-two worms. It is said to gain an entrance into the body by means of drinking water, but this is doubtful. So far as I know, there is no case on record in which the worm has been found within the abdomen. It is in all probability deposited beneath the skin, and this theory is supported by the fact that it only occurs in those who walk bare-footed either constantly or occasionally, that it principally occurs in the lower extremities, that in those cases in which it occurs on the trunk or arms it is in persons who have slept on the ground, or who have carried earth or water. In 1190 cases I saw, the feet were affected in 556 cases, the legs in 274, the thighs in 104, the scrotum in 4, the penis in 3, labia majora in 3, abdominal walls in 1, the breast in 2, the back in 143. I never myself saw it in the head, arms, or elsewhere. The average time of incubation after the ova is deposited within the skin appears to be from three to six months. It is only when the worm arrives at maturity that the patient first becomes really aware that he has contracted the disease. He suffers from a severe attack of fever, the stomach becomes irritable, bilious vomiting takes place, and attention is now first attracted to the situation of the guinea-worm. Intense itching is felt, with a sensation of a thin cord underneath the skin; occasionally also a small pimple or blister can be seen, and when this occurs in a district infested by the guinea-worm, it may generally be regarded as a sufficiently diagnostic sign, especially if accompanied by any swelling.

The development of this characteristic blister or vesicle always coincides with the advance of the worm to the surface of the body. The blister may sometimes be as large as half a walnut, and may be attended also by an eruption resembling nettlerash. When this vesicle is opened, it is seen to be filled with either a glary, whitish fluid, or with the reticular portions of the true skin, the areola being a meshwork filled with serum, at the centre of which a small aperture is visible, in which the extremity of the worm will be found. As the worm protrudes from the skin, it should be secured to a small piece of twig or crowquill and gradually withdrawn. Great care must be taken not to break the worm, as if it is broken extensive and destructive inflammation in the connective tissue occurs. The prognosis in general is good if the case be treated carefully, but it may cause distortions of the lower extremity, such as talipes equinus, permanent enlargement of the internal maleolus, permanent contraction of the leg or the thigh, and sometimes permanent anchylosis of the knee joint, or gangrene of either toe, foot, or leg.

Preventive Treatment.—Never walk bare-footed in a region where the worm is endemic; do not bathe in muddy pools.

After walking through swamps, see that the skin is well rubbed with a rough towel or flesh brush. All drinking water must be filtered.

Internal Treatment.—Nitrate of potash in 2 dr. doses given in butter-milk is said to cure guinea-worm in from three to five days, and the application of electricity to the worm-affected part may cause its death. Assafœtida in 5 to 15 gr. doses daily for a week has cured many cases. It is said also that feeding a patient on sugar-candy for twenty-four hours, without any other food or drink, may cause the death of the worm.

Extraction of the Worm.—After securing the worm, attempts should be made to extract it every twenty-four hours. As much as 6 or 8 inches a day may be extracted and wound upon the quill, which should then be fastened parallel to the limb with two pieces of strapping, and the part dressed with lint soaked in a solution of alum, 8 grs. to the ounce. This prevents the part becoming dry, and also strengthens the worm, and so tends to diminish the danger of its breaking. The natives are very skilful in extracting the worm by making an incision over it and rapidly turning it out, but this requires great skill.

Constitutional symptoms, when they arise, must be treated on general principles, and if malaria complicates matters, the use of quinine must be energetically pushed.

Egyptian Chlorosis.

This disease is common in Egypt. It is caused by the ingestion of the *Anchylostomum duodenale,* from which it is reported that a fourth part of the population suffers. It is said to be a stage in the development of the *Dochmius trigonocephalus* of the dog. It attaches itself to the lower portion of the human duodenum and jejunum. The symptoms caused by the presence of this worm are those of pernicious anæmia. For debilitated individuals it may prove fatal in a few weeks. In well-fed persons the disease may exist for two or three years. It is found that the best treatment to get rid of the worms is the administration of the milky juice of the *doliaria* or of the *Carica dodekaphylla*, or Thymol is often of great use. Dr Sandwith gives to adults 2 grms. at 8 A.M. with 25 grms. of brandy, and repeats the dose at 10 A.M. At noon a dose of castor-oil should be given. Care should be taken in very debilitated subjects. If necessary, this treatment may be repeated in a week. It is well to remember that the patient should keep perfectly still after taking the medicine, as giddiness and faintness are apt to ensue. The brandy is given both to dissolve the drug and also to prevent collapse. The subsequent treatment of the anæmia which has been produced must be carried out upon general principles. It will be found that Levico water is very useful in improving the condition of the blood, but as it would not be easily carried, iron and arsenic should be given thrice daily.

Snake-Bites.

One or two hints with regard to the prevention of snake-bites may not be out of place. In order to prevent snakes from entering a house, it is advisable to have a path four or five feet wide encircling it, and covered with rough stones. Keep the verandahs free from frogs, especially during the wet season. A frog is a temptation which a snake has little or no power to resist (Waring). Place a coil of camel's-hair rope round the bed; snakes will not cross it. Never get out of bed during the night with bare feet without a light and first seeing if the way is clear. If a snake is seen coiled up or in an apparently lifeless state in the road, it should be avoided, as it is probably only torpid with cold, not dead (Dr Chevers). It is well to remember that a poisonous snake-bite may be diagnosed by the *two* well-marked wounds made by the fangs. In treating snake-bites, it is probable that the hypodermic injection of strychnine, as recommended by Dr A. Müller, is the best treatment we possess. "Nothing less than 16 ms. of the liquor. strychniæ (B.P.), in very urgent cases even 20 or 25 ms., should be injected into any person over fifteen years of age. Even children may require these large doses, as they are determined by the quantity of the poison they have to counteract, and are kept in check by it.

The action of the antidote is so prompt and decisive that not more than fifteen or twenty minutes need elapse after the first injection before further measures can be decided on. If the poisoning symptoms show no abatement by that time, a second injection of the same strength should be made promptly, and, unless it is followed by a decided improvement, a third one again after the same interval. As the action of strychnine, when applied as an antidote, is not cumulative, no fear need be entertained of violent effects suddenly breaking out after these large doses repeated at short intervals."

Yaws or Framboesia.

This disease consists of an eruption of yellow or reddish-yellow tubercles, which gradually develop into a moist exuding fungus, without constitutional symptoms, or with such only as result from ulceration and prolonged discharge, namely, debility and prostration. Its predisposing causes are filth, vitiated atmosphere, and want of animal food in a tropical climate. It is more common in the coloured than in the white population. It is epidemic and contagious by actual contact. The period of incubation ranges from three to ten weeks. It is not liable to recur. Its duration is from two to four months, but it may last for a year. It frequently runs in families, and is apt to be communicated by clothing, especially by boots. Children are most subject to it, then men, lastly women. The disease often begins with a severe febrile attack; in a few days small spots appear, principally on the face, in the axilla, in the neighbourhood of the groin, or on the feet. They increase gradually until they are as large as a pin's head, the surrounding skin acquiring an unhealthy aspect. In about a week these little tubercular swellings exude a thin sanious fluid, forming dry scales or scabs. The surface remains covered with these scabs for a week or ten days, if undisturbed, during which time a fungoid excrescence grows underneath it, so as to form a projecting mass one or two inches in diameter. The skin around is hard and firm. Crops of yaws arise at different periods. After maturity they may remain stationary for some weeks. One excrescence in each group is generally larger than the rest, and is called the "mother" or head yaw. The disease runs a definite course, exactly like the exanthematous eruptions. When the ulcerations heal they leave a pigmented stain, but the "mother" yaw leaves a large scar.

Treatment.—The preventive treatment is cleanliness, good diet, and the avoidance of contact with persons suffering from the disease or with their clothing.

The general treatment must be guided by the symptoms present, as the disease cannot be abbreviated. Full animal diet should be given, and perfect cleanliness enjoined, with exercise and plenty of fresh air. Tonics and alteratives are required from the first; arsenic is extremely useful, so are the mineral acids, sarsaparilla, and bark. Iodide of potassium also is given, in combination with liquor arsenicalis and alkalis, and is exceedingly useful when the ulcers are indisposed to heal.

With regard to local applications, carbolic acid solutions, or dilute nitrate of mercury ointment, or creosote in the strength of 1 dr. to 1 oz. of lanoline, should be employed. Authorities differ as to the administration of mercury in this disease; it should at any rate be avoided in debilitated subjects.

Elephantiasis Arabum.

This is a chronic disease, which may be said to be characterised by an enormous hypertrophy of the skin and subcutaneous tissue, caused by recurrent inflammation of the vessels and lymphatics in the part affected. It is unnecessary to refer at any great length to this disease, because it is very rarely that white residents in Africa are affected by it. Various parts of the body are attacked—the legs, scrotum, pudendum, abdomen, and breasts; most chiefly, however, it is found affecting either the legs or the scrotum. Males are most frequently attacked at about the age of puberty. It is non-contagious; it is not hereditary; its cause is unknown.

The treatment, when the disease has once become manifest, is removal from the area in which it was contracted. It was once supposed that tying the femoral artery would cure the growth in the leg, but that treatment is unsatisfactory. Persistent strapping from the foot upwards has also been recommended, but it likewise does little good. The scrotum may be removed, and even enormous tumours weighing 40 to 60 lbs. are often successfully treated in this manner. In a case I treated lately, in which the disease was limited to the body and the thighs as far as the knees, I obtained a cure, by enjoining absolute rest, giving the patient a hot bath every day, a moderate amount of food, chiefly milk, having the patient regularly massaged, and by applying the constant current for twenty minutes each day. A mixture was prescribed containing quinine, arsenic, iron, and strychnine, and the bowels were regulated by the frequent administration of aperients.

Leprosy.

This is a disease caused by a bacillus which is chiefly found in the exudation cells, but also in the diseased connective tissue, more rarely in the blood-vessels. There are three varieties—tuberculated, non-tuberculated, and anæsthetic. The recent Commission which has been held on the subject does not believe that the disease is either contagious or hereditary. It is practically incurable, but benefit may be obtained by the internal and external administration of chaulmoogra oil, and quite recently extract of the thyroid gland has been given with marked success. It has been stated that the production of leprosy is due to extremes, frequent and rapid transitions of temperature, but it is not so. Various articles of diet have been blamed for its cause —fish diet, salt or rotten fish, immoderate use of pork, and the use of decomposing rice or maize, but none of these articles of diet can be its exciting cause.

In Central Africa the natives certainly believe that the disease is contagious, and they also believe that sleeping in a hut which has been inhabited by a leprous patient is dangerous. It is, indeed, necessary to avoid contact with lepers as much as possible. White men in Africa rarely, if ever, suffer from this disease.

Yellow Fever.

Yellow fever is a pestilential contagious disorder of a continuous and special type, depending for its origin and spread on a temperature not lower than 70° F. As a general rule it occurs but once in a lifetime. Its spread is favoured by the gathering together of persons born in a cold climate.

Etiology.—Yellow fever is entirely distinct from malaria. Its production requires a temperature of from 68° to 70° F. When once originated, however, an epidemic may spread at a lower temperature, but it dies out if the temperature falls to freezing point. The influence of moisture in the air constitutes a second factor in the production of yellow fever. Abundant continuous rain does not infrequently bring an epidemic to an end, probably by modifying the temperature, but a certain saturation of the atmosphere is an essential condition for the production of the disease—probably 74 per cent. of moisture. Epidemics cease when the amount of moisture is as low as 58 per cent. The only influence which wind has on yellow fever is by its modifying the temperature. The disease rarely leaves the sea coasts and the shores of large rivers; it arises in the filthy quarters of towns, in the centres of poverty where the people are densely crowded. The geological characters of the soil have apparently no connection with the production of the disease. It is most interesting to notice the influence which circumstances of race, nationality, and acclimatisation exert upon the disease. Where it is endemic or epidemic, newly-arrived strangers, or such persons as have not yet become fully acclimatised, are the persons who suffer most. This is well seen if a large body of troops or a shipload of emigrants arrive at any place where the disease already exists, though it may be very mildly. An epidemic at once springs up, and the new arrivals are the first persons attacked. The degree to which this proclivity of strangers exists will depend to a great extent on their nationality, that is, on the mean annual temperature of their native country. The liability to attack, as well as the mortality amongst the newcomers, bears a close relation to the distance from the equator of their place of birth. Although no absolute immunity is acquired by acclimatisation, yet it is true that a certain amount of immunity is possessed by those who have lived for a considerable period in any locality constantly or frequently visited by the disease. The chances of immunity appear to be always in direct proportion to the lengthened residence at the headquarters of the disease, but no protection is acquired except by those who have passed through a previous epidemic period without quitting the country. Any benefit, however, gained by acclimatisation is immediately lost on change of residence, even though that change be to a healthier locality. This remark applies equally to negroes and white men, but negroes suffer far less from yellow fever than do the whites.

The nature of the yellow fever poison has been found by Dr Domingos Freire to be a specific cryptococcus. He has also found out that this micro-organism secretes an alkaloid resembling a ptomaine, which acts as a violent poison. With regard to contagion, there is no doubt that it may be conveyed by fomites or merchandise, as also by ships, and it can be transported farther by sea than on land. Hence the necessity during an epidemic of completely isolating vessels in a harbour. It does not appear that contact with the sick has power to spread the disease. Electricity appears to have a singular and baneful influence upon persons suffering from yellow fever.

It is impossible in the space at my disposal to detail the symptoms of yellow fever, but there are a few well-marked symptoms which deserve notice. First, the attack is sudden, there is a want of correlation between the pulse and temperature, albuminuria is invariably present, the patient suffers from the black vomit, from a general hæmorrhagic tendency, and from a yellow discoloration of the skin, often, too, from suppression of urine.

Prophylactic Treatment.—Avoid the yellow-fever season if possible, namely, the hot and rainy season; avoid chills by wearing proper clothing; avoid exposure to the sun as much as possible. Individuals attacked by the disease should be isolated. Residences should be chosen at the highest altitudes possible, in any case the second storey is preferable to the first, and in camp the ground should be disturbed as little as possible. Strictest disinfection should be employed. The water and food supply should be well cared for, and it should be remembered that the yellow-fever bacillus has been found in the soil. Exposure during the night is inadvisable, for Carlos Finlay has demonstrated that the disease can be communicated by the mosquito. Yellow fever is also a disease in which quarantine is necessary and effectual; not only is it necessary to place persons coming from an infected place under observation, but their clothing and goods should be thoroughly disinfected.

Inoculation.—Since the researches of Freire and Finlay, it is possible to employ protective inoculation against yellow fever. Finlay allows a mosquito to bite a yellow-fever patient and then a healthy person; a mild attack of yellow fever is induced, protecting the person thus treated from a subsequent attack. Dr Freire, having isolated the yellow fever micro-organism by a series of cultivations, attenuates it and produces a fluid which almost entirely protects persons from yellow fever. In no case has the inoculation been harmful, and the mortality of those inoculated was only rather more than 0·4 per cent. in 10,881 cases inoculated (1890), showing that this procedure confers almost certain immunity from the disease.

Treatment.—With regard to the treatment of yellow fever, little can be said. It is important that each patient should be allowed at least 2000 cubic feet of space; the room should be kept at an equable temperature, and the patient protected from draughts; indeed, many advise the treating the patients in tents or in the open air. Absolute rest in a recumbent position must be rigidly maintained. The patients must be lightly but warmly clothed, heavy blankets being avoided. Doctors and nurses should be cheerful, and encourage the patients as much as possible.

With regard to drugs, no specific for yellow fever is known, and, practically, symptoms must be treated. I should be inclined myself to recommend either of the two following treatments. The first is recommended by Nelson. He gives

15 grs. of quinine, half an ounce of sulphate of sodium, dilute sulphuric acid, and tincture of cardamons, at first. If after the first two days the temperature remains above 100° F., with the usual symptoms of yellow fever, he adds phosphoric acid largely diluted with water, every hour or two. Diaphoresis is induced by vapour baths; the diet consists of iced milk and beef broth in small quantities at frequent intervals. On the other hand, Sternberg recommends bicarbonate of soda 150 grs., bichlorate of mercury $\frac{3}{10}$th gr., water 2 pints; an ounce and three-quarters to be given ice-cold every hour. This treatment is slightly modified by Mitchell, who increased the dose of the bicarbonate of soda to 4 drs., and the bichlorate to half a grain. When patients are thus treated from the first day, vomiting rarely occurs. Diuresis is well maintained. After the eighth or tenth day it is necessary to suspend the bicarbonate of soda and give stimulants, and to combat the adynamia and the hæmorrhages, etc., with the customary measures. For the vomiting I believe turpentine is the best remedy; it may be administered either by the mouth or by enemata, and the body may be rubbed with a mixture of turpentine and olive oil. If suppression of urine occurs, I know of no better treatment than to apply a digitalis leaf poultice to the loins, and to throw up the rectum a pint or more of ice-cold water at regular intervals.

The discharges of the patient are best disinfected with either chloride of lime or perchloride of mercury. Bedding and clothing are best destroyed by fire. Hospital wards or the hold of a ship should be fumigated with nitrous acid for at least forty-eight hours, and then all the woodwork washed with chloride of lime. For disinfecting the bilge-water of ships, chlorate of lime must be employed.

Typhoid Fever.

I have only a few remarks to make on this subject. Typhoid fever certainly exists in Africa, and it is also certain that the death-rate is higher there than it is in more temperate zones. I hold the view that the disease is due to

Eberth's bacillus, and I have only a few words to say with regard to the prevention of the disease.

Typhoid fever is most prevalent during the hottest months in Africa, and it should be remembered that sandy soil favours its spread, as the dried excreta of patients may be conveyed by the wind unless care be taken. The utmost care should be taken to ensure the fullest sanitary precautions. The excreta must be properly disinfected, and the water-supply should not only be carefully selected, but all water should be filtered and boiled. Milk, too, deserves special attention. The meat-supply should also be investigated, and all tainted supplies rigorously rejected. It is necessary also to pay attention to the vegetables, as undoubtedly they may carry the infection. All patients should be thoroughly isolated, and their bedding and linen destroyed. It is very necessary, in my opinion, to get rid of the idea that typho-malarial fever exists, and in cases of doubt a bacteriological investigation should be made, which failing, the disease should be treated by quinine, and if it does not succeed in reducing the temperature, then the case should be treated as one of typhoid fever. The cases which have been designated typho-malarial fever are in reality severe cases of remittent fever lapsing into a typhoid state, or else enteric fever modified by its occurrence in a patient who has previously suffered much from malaria, or occurring simultaneously with an attack of malarial fever (Duncan).

Tropical Dysentery and Diarrhœa.

Dysentery has practically the same distribution as malaria in Africa, and there are only some minor differences met with in the distribution of the two diseases. It does not always follow that the maximum intensity of the diseases coincides.

In referring to the etiology and prevention of dysentery, I may, to economise space, include diarrhœa as well, for, although I believe true tropical dysentery to be due to the amœba discovered by Cartulis of Alexandria, which discovery has been confirmed by American observers (see

Johns-Hopkins Hospital Reports), yet both diseases may to a certain extent be combined, and the precautions necessary to avoid the one are those which would prevent the other.

Both diseases are most prevalent in the hot and rainy seasons; both are liable to be produced by rapid alternations of temperature and by chill. Therefore persons in Tropical Africa should avoid chill by means of careful clothing, and by the invariable use of a cholera belt. Excessive exertion also predisposes to both diseases, and both are especially met with in damp, swampy places, and in all districts where the soil is impregnated with decaying vegetable débris. The drinking water should be as pure as possible, and in cases where the water-supply is doubtful, it should be filtered and boiled. All stagnant water should be, if possible, avoided. It is also of importance to remember that both a monotonous diet and salt rations frequently induce diarrhœa, and predispose to dysentery. Unripe fruit, and especially over-ripe fruit, should be avoided. There is no doubt that in Africa many cases of diarrhœa and dysentery are induced by exposure to the night air, and also by sleeping on the ground. Where they are prevalent, it is well to isolate the patients, and to carefully disinfect their excreta; and finally, it must be borne in mind that malaria may complicate both diseases, and that then, unless the malarious factor is taken into account, the disease cannot be cured.

One may summarise the predisposing causes of dysentery and diarrhœa as follows:—Frequent exposure to malaria, great bodily fatigue or excessive anxiety and mental distress, excess in the use of alcohol and tobacco and narcotics, overcrowding, the use of tainted food or the prolonged employment of salt provisions, and lastly, the too frequent employment of strong purgative medicines. The exciting causes of these diseases are—unwholesome drinking water, the use of indifferent food, great and sudden vicissitudes of temperature and chill, impure air, intestinal worms, and abscess of the liver.

Nothing need be said as to the treatment of diarrhœa, as this must be carried out on general principles; but with regard to dysentery, my experience points to the advisability of treating it in Africa with large doses of ipecacuanha. This I consider the only treatment of any practical value. After sending the patient to bed, a mustard plaister should be applied to the epigastrium, and 30 drops of laudanum given at once. After half an hour 30 or 40 grs. of powdered ipecacuanha should be given, in as small a quantity of fluid as possible. A similar dose may be repeated in twelve or twenty-four hours if necessary; after this, during the succeeding days, the dose should be gradually lessened to 10 or 15 grs. a day, until the patient has perfectly recovered. In very severe attacks, as much as 2 drs. of the powder have been given without producing vomiting. Fairly large doses of quinine are required in all cases of malarial dysentery. In the treatment of the scorbutic form of dysentery, lime juice, fruit, and vegetables should be given, with as much animal food as the stomach will bear. In treating natives in Africa, the great difficulty is to ensure proper diet, for, unless the patient is carefully watched during convalescence, a relapse will follow the least indiscretion. A sea voyage is beneficial when a patient is convalescent, but it is not to be recommended during the continuance of the attack.

Malaria.

There are few regions in Africa where malaria is not a scourge, and those few have been indicated in my survey of the various African regions.

I may say at the outset that I believe malaria to be produced by the hæmatozoon discovered by Laveran. His researches have been confirmed by observers in Europe, India, America, and Africa. The life-history of the hæmatozoon we do not know, and therefore we can only state that it requires a mean annual temperature of 40° F., and considerable moisture; also, other things being equal, the greater amount of organic matter in the soil, the more virulent will the production of the disease be.

Of the various types of malarial fever, the intermittent is the most widely distributed, the remittent and pernicious fevers only being met with in comparatively limited areas, and in Africa these are found upon the coasts, along the rivers, and in the water-logged swampy districts at an altitude of under 3000 feet. The quotidian and tertian types of intermittent fever are the ones most frequently met with. The type of fever stands in a definite relation to the intensity of the malarial process; thus we find that the tertian type prevails in those regions of Tropical Africa where the malarial process, although indigenous, is more sparingly produced. The frequency of the occurrence of the quotidian type of fever, either in endemic areas or in epidemics, is in direct proportion to the severity of the process. When an epidemic wave of malarial fever passes over a district, the tertian type is seen at its outbreak, whereas at the height of an epidemic, or whenever it assumes a severe character, the quotidian type obtains; and as the outbreak of sickness abates, one meets with a return to the types of fever having a longer interval between the paroxysms. In the higher latitudes in Africa, and also in the higher altitudes, the quartan type of fever makes its appearance.

All races suffer from malaria, although the Negroes suffer less from it, always provided that they do not migrate. In Africa, as in all parts of the world, strangers suffer more severely from it than does the indigenous population. The incidence of malaria is, to a certain extent, governed by the seasons. In those places where it is endemic, it occurs all the year round, but where it is only slightly developed there are two maxima, one in spring and one in autumn, and a considerable decrease in the disease in the interval. In Africa, in the worst malarious regions, the disease is practically most rife at the beginning and at the end of the rains. The relation which malaria bears to heat is as follows: the greater the mean summer temperature (moisture, etc., of course being taken into account) the more malaria, the amount of malaria decreasing with the mean annual temperature of the place.

The influence of rain or moisture has undoubtedly much to do with the production and spread of malaria. With reference to the rains, the malarial poison is most virulent either when they set in after a long period of heat, or when the rains cease and give place to warm dry weather. An endemic outbreak of malaria and its epidemic spread are both notably diminished at the height of the rains, if they are very abundant, but the malarial process is developed more abundantly in wet than in dry years. These remarks are well illustrated by the behaviour of malaria in different districts. In Equatorial Central Africa, where the rainfall is fairly equally distributed throughout the year, the amount of the disease remains practically the same, but in regions, *e.g.*, along the White Nile to the north of Lado, where there are two wet seasons, a rise and fall in the production of malaria is manifest. But it is not alone rainfall which influences the production of the disease. Drainage from rivers, lakes, and pools, periodical or irregular inundations, and the height of the sub-soil water, influence its production. This last point is of importance, because it explains the occurrence of malaria in localities remote from river basins, in the Sahara, in Darfur, etc.

Although the geological characters of the country would appear to exert little or no influence on the production of the disease, it is the contrary with the physical characteristics of the soil. Clay, loam, clayey marl, and marshy soil are most favourable to the production of the disease. A porous chalky soil is less favourable, and a sandy soil least so, provided that they do not rest either upon clay or firm rock. Again, the greatest amount of malaria will be found where the organic matter in the soil is greatest. It is also an undoubted fact that changes in the soil, produced by cultivation or its neglect, influence the production of the disease. In well-cultivated countries malaria disappears, and if marshy districts are well drained or completely covered with water, the disease is also diminished.

The configuration of the ground also causes a local effect, for it is found that the disease is more virulent in the lowest altitudes; even the difference of 50 or 100 feet in altitude in a plain makes a considerable difference as to the salubrity or otherwise of a given spot.

Winds act only indirectly on malaria, as, for instance, by moderating temperature; they may, however, act directly in the diffusion of the poison or in preventing it exercising its potent effects. Wind may carry the malarial poison from a marsh to a distance of some two or three miles. Malaria may rise to a height of 600 or 700 feet in a calm atmosphere; wind will prevent this vertical diffusion.

Water can convey the malarial poison, but it is unknown at present how far it can carry it.

The poison is ponderable, and affected by barometrical pressure, and it is possible also that food may be contaminated by it.

The influence of jungle and forest on malaria must also be noticed, because so much of Central Africa is covered by one or other. In a jungle, malaria is intensely virulent, and, owing to want of ventilation by the penetration of winds, it is there in a very concentrated form. In forests the production of malaria is to some extent lessened by the shade, and by the trees diminishing the amount of rainfall reaching the soil. There is no doubt that forests often act as a screen or filter, and therefore protect the district from malaria when they lie between it and a marsh.

With regard to the prevention of malaria, much may be done by careful drainage, not only of the surface, but of the sub-soil water. Great care should be exercised in the choice of a residence, ravines being avoided, also the neighbourhood of swamps. Settlements, and even individual houses, should be on the most elevated situations, and it should be remembered that malaria is less rife in the centre of towns, especially if the streets are narrow and crooked. The proposal to build houses in the form of a hollow square is to be commended, and in all cases they should be constructed with a blank wall to the prevailing wind, especially if that wind blows over a marsh. The thick jungle in the neighbourhood of a settlement should be destroyed, but care should be taken not to remove either thickets or trees between a settlement and a marsh. The ground under and around a habitation should be rendered impervious to water and air, and the sleeping rooms should be in the second storey. In camping out even, considerable protection may be obtained by sleeping in a mosquito curtain

Lizard, adding "is much less plentiful than in many other districts." The only localities for it in the county known to my friend Mr R. S. Anderson, Peebles, are Craigburn Quarry, and the Bitch Craigs at the head of Manor, but doubtless there are many others.

As regards East Lothian, I had an opportunity in the summer of 1889 of seeing a specimen, which had been captured a few days before in the vicinity of Haddington, and Dr Hardy informs me it occurs sparingly on the eastern confines of that county and Berwickshire, whence, in 1834, it was recorded by the minister of Cockburnspath as "occasionally seen in the sunny heaths" ("New Stat. Acc." of the parish, p. 300). Mr A. Hepburn, whose excellent notes on East Lothian birds are well known to readers of MacGillivray's classic work on British Ornithology, tells me, however, that he never met with it in the county during the period he resided at Whittinghame, close to the Lammermoors. Other correspondents also tell me they have never met with it in the county, so we may assume it is far from common there.

In Fifeshire I have noted it on a heath between Thornton and Wemyss; and from Mr W. Berwick, Stravithie, St Andrews, I learn it is likewise found occasionally in the more eastern parts of the county—he mentions Peat Inn, and Chesters, near Dunino, as localities where it has been captured. Though I have no information on the point, I do not doubt it occurs in suitable spots in the western section of the county also. At Brankston Grange, a few miles to the west of Fife, Mr J. J. Dalgleish captured one in 1854, but this is the only one he has ever seen there.

In the upper, or western, end of the Forth valley, it is, as might be expected from the nature of the country, more common than in the lowland parts. In April 1892 I discovered one under a stone near the top of the crag behind Callander, and I then ascertained that it was frequently seen in that neighbourhood.

All the specimens I have examined from our district have been more or less of the usual greenish-brown colour, but a little farther afield, namely at Fearnan, Loch Tay, I captured

22nd days, omitting it on the 17th to the 20th day. In remittent fever the quinine should be given when the temperature falls, however small the fall may be. In pernicious fevers a hypodermic injection of the drug is indicated. I think the bisulphate of quinine, with a little carbolic acid, and glycerine and water, at a temperature of 100° F., is the best solution to use for this purpose. In severe remittent fever I consider Warburg's Tincture exceedingly useful, but I invariably prescribe it in the tabloid form, which has been made for me by Burroughs, Wellcome, & Co.

I feel that my task has been very inadequately performed, but I have endeavoured to do my best within the limits imposed on me. The diseases of Africa, and their distribution, are represented by symbols upon the Map, which, if read with reference to altitude, will indicate broadly the unhealthy and the comparatively healthy areas of the continent.

I cannot conclude without stating it to be my definite opinion, that as in India, so in Africa, the progress of medicine and hygiene will before long conquer most of the obstacles to the civilisation of that continent.

APPENDIX.

The following Table shows the distribution of various diseases in different areas in Africa. The amount of disease is illustrated by the number of stars (*).

	Morocco.	Algiers.	Tunis.	Tripoli and Barca.	Egypt.	Sahara.	Senegal.	Sierra Leone.	Gold Coast.	Niger Delta.	Bight of Biafra.	Congo.	Cape Colony.	Natal, Zululand.	Transvaal.	Bechuanaland.	East Coast Region.	S. and E. Central Africa.	Abyssinia.	Seychelles.	Madagascar.	Mauritius.
Malaria, ...	*	**	**	*	*	*	***	***	***	***	**	***		*	*	*	***	**	*		**	**
Typhoid Fever, ...	*	***	*	*	**	**	*	*			*		**	**	**	*	*	**	**		**	**
Typhus Fever, ...	*	*		*									*?									
Relapsing Fever, ...	*	*			**														*			
Cholera, ...	*	**	*	*	*		*	*									*	*	*			
Dysentery, ...	**	***	**		***	**	***	**	*	***	**	*	**	**	**	**	***	**	**	**	**	**
Diarrhœa, ...	**	***	**			**	***	**	*	***	**	*	**	**	**	**	***	**	**		***	**
Small-pox, ...	**	**	*		**		***		**				*	*		*	***	**	**			
Scarlet Fever, ...			*		*									*		*						
Measles, ...		**	*		*		**					*	*	*	**	*	*	*				
Phthisis, ...	*	*	*		*	*	*	*	*		**	**	**	*				*		*	*	*
Respiratory Diseases, . . .	*	**	*		*	**	**	**		***		**	*	*	*	*	*	**	**		*	

Leprosy,	***	***	***		***		**	*	**	*	*	*	*		*		*	*	**	**	**	**
Rheumatism Acute,	*	*	⁂		⁂		⁂		*		⁂	**				**	*		⁂			
Rheumatism Chronic,	**		⁂		⁂		⁂		**				⁂				*	**	⁂		**	
Syphilis,	***	*	***		***	**	***		***				**			**	***	**	***	**	**	**
Ophthalmia,	***				***											***	**	***				***
Hepatitis,		**	*		**		**		*	*	*	**				*	**	*		**	**	**
Abscess of Liver,	*	**	*		**		**	*	*	*	*	*					*	*				
Oriental Sore,	**	***	**		*																	
Hæmaturia,					**								⁂	**				*				
Goitre,		*									*								*			
Diphtheria,			**											**	**		**					
Plague,	*	*	*	*	*													*				
Dengue,				*	*		**										**	*				**
Yellow Fever,							**	***	**	*												
Filaria,					**							*										
Yaws,							*	**	***	*	*	***						*				
Sleeping-Sickness,							**	**				**										
Beri-Beri,								**	*			⁂					*				**	*?
Elephantiasis arabum,	**				**		*	*	**	*		*					**	**				**
Anchylostomum duodenale,					⁂		*					**										
Guinea-Worm,					**		**	*	*	**		*						**				

XXXIII. *The Reptiles and Batrachians of the Edinburgh District.*

By WILLIAM EVANS, F.R.S.E.

(Read 21st March 1894, and revised for publication to 18th June.)

In laying the following account of the classes Reptilia and Batrachia before the Royal Physical Society, I do so not on the strength of any important discoveries, for I have none to announce, but simply as a contribution towards a fuller and more complete history of the fauna of the district around us than we yet possess—an object, it seems to me, well worthy of more combined effort on the part of resident naturalists than it has hitherto received. The completion of such an extensive piece of faunal work, means of necessity many years and many labourers, but its realisation is surely worth an effort; and it is gratifying to know that at this moment several groups, both vertebrate and invertebrate, are receiving systematic attention at the hands of Fellows of the Society.

The number of Reptiles it has been customary to place on the British list is nine, but two of them, namely, the Hawk's-bill Turtle (*Chelone imbricata*) and the Leathery Turtle (*Dermochelys coriacea*), being merely accidental visitors of the rarest description, cannot properly be regarded as part of the fauna of these islands; and as regards a third, namely, the Green Lizard (*Lacerta viridis*), Mr G. A. Boulenger, of the British Museum, informs me there is no evidence of its existence in any part of Great Britain. Excluding these three then, we are left with six as the sum total of the British Reptilia. All are to be met with in England; but it may well be doubted if more than three of them occur in Scotland as indigenous animals,—these are, the Viviparous Lizard (*Lacerta vivipara*), the Slow-worm (*Anguis fragilis*), and the Adder (*Vipera berus*). The doubtful species are the Sand Lizard (*Lacerta agilis*), the Ringed Snake (*Tropidonotus natrix*), and the Smooth Snake (*Coronella austriaca*). Examples of the Ringed Snake have, indeed, been captured in the south of Scotland, but under circumstances which seem clearly to point to its artificial introduction. Genuine captures of the other two, however, have yet to be produced,

—no statement worthy of serious consideration concerning the occurrence of the true Sand Lizard being on record so far as I know, and the evidence for the Smooth Snake resting on the more than doubtful reference of Sowerby's *Coluber dumfrisiensis* to that species.[1]

The Edinburgh list comprises the three species common to the rest of Scotland; and (but only provisionally, and therefore within square brackets) the Ringed Snake, several examples of which, in all probability escapes or their direct descendants, have been captured in the suburbs of the city.

In Britain the class Batrachia is represented by seven species, four belonging to the tail-less and three to the tailed division. All of them, except the Edible Frog (*Rana esculenta*)—a species, by the way, whose claim to indigenous rank in any part of Britain is not yet free from doubt—extend their range north to Scotland. Of the six which reach Scotland, five, namely—the Common Frog (*Rana temporaria*), the Common Toad (*Bufo vulgaris*), the Warty Newt (*Molge cristata*), the Smooth Newt (*Molge vulgaris*), and the Palmated Newt (*Molge palmata*), are all more or less common in the vicinity of Edinburgh. The Natterjack Toad (*Bufo calamita*)—a species of decidedly western distribution in these islands—has been recorded for the extreme south-east corner of the district; but the record, now half a century old, requires confirmation.

The following tables exhibit in a concise form the facts embodied in the above remarks.

Class and Order.	Britain.	Scotland.	Edinburgh.
REPTILIA—			
1. Sauria, . .	3	2	2
2. Ophidia, . .	3	1 or ? 2	1 or ? 2
Total, . .	6	3 or ? 4	3 or ? 4

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[1] Mr G. A. Boulenger has recently given it as his opinion (Zoologist, 1894, p. 10) that the specimen in question belonged to a North American species (*Coronella doliata*, L.) !

APPENDIX.

The following Table shows the distribution of various diseases in different areas in Africa. The amount of disease is illustrated by the number of stars (*).

	Morocco.	Algiers.	Tunis.	Tripoli and Barca.	Egypt.	Sahara.	Senegal.	Sierra Leone.	Gold Coast.	Niger Delta.	Bight of Biafra.	Congo.	Cape Colony.	Natal, Zululand.	Transvaal.	Bechuanaland.	East Coast Region.	S. and E. Central Africa.	Abyssinia.	Seychelles.	Madagascar.	Mauritius.
Malaria,	*	**	**	*	*	*	***	***	***	***	**	***		*	*	*	***	**	*		**	**
Typhoid Fever,	*	***	*	*	**	**	*	*			*		**	**	**	*	*	**	**		**	**
Typhus Fever,	*	*		*									*?									
Relapsing Fever,	*	*			**														*			
Cholera,	*	**	*	*	*		*	*									*	*	*			
Dysentery,	**	***	**		***	**	***	**	*	***	**	*	**	**	**	**	***	**	**	**	**	**
Diarrhœa,	**	***	**			**	***	**	*	***	**	*	**	**	**	**	***	**	**		***	**
Small-pox,	**	**	*		**		***		**				*	*		*	***	**	**			
Scarlet Fever,			*		*									*		*						
Measles,		**	*		*		**					*	*	*	**	*	*	*				
Phthisis,	*	*	*		*	*	*	*	*		**	**	**	*				*		*	*	*
Respiratory Diseases,	*	†	*		*	**	**	**		***		**	*	*	*	*	*	**	**		*	

Leprosy,	***	***	***		***		**	*	**	*	*	*	*		*		*	*	**	**	**	**
Rheumatism Acute,	*	*	***		***		***		*		***	**				**	*		***			
Chronic,	**		***		***		***		**				***				*	**	***		**	
Syphilis,	***	*	***		***	**	***		***				**			**	***	**	***	**	**	**
Ophthalmia,	***				***											***	**	***				***
Hepatitis,		**	*		**		**		*	*	*	**				*	**	*		**	**	**
Abscess of Liver,	*	**	*		**		**	*	*	*	*	*					*	*				
Oriental Sore,	**	***	**		*																	
Hæmaturia,					**								***	**				*				
Goitre,		*									*								*			
Diphtheria,			**											**	**		**					
Plague,	*	*	*	*	*	*												*				
Dengue,				*	*		**										**	*				**
Yellow Fever,							**	***	**	*												
Filaria,					**							*										
Yaws,							*	**	***	*	*	***						*				
Sleeping-Sickness,							**	**				**										
Beri-Beri,								**	*			***					*				**	*?
Elephantiasis arabum,	**				**		*	*	**	*		*					**	**				**
Anchylostomum duodenale,					***		*					**										
Guinea-Worm,					**		**	*	*	**		*						**				

by the fact of this interesting southern race having been captured in the city."

The 1893 specimen is, I understand, the Ringed Snake which Professor Duns informs me was recently obtained in the garden of a friend of his at the Grange.[1]]

VIPERA BERUS (*L.*). THE ADDER.

Fortunately, as the majority of people will no doubt think, the Adder or Viper—the only poisonous British reptile—is confined to the outskirts of our district, and even there it is very local, and far from common till we reach the highland country beyond Stirling on the one hand, or proceed well into the Lammermoors on the other.

We may safely assume, I think, that in bygone days, when much of what is now under cultivation was wild heath and common, or natural copsewood, the Adder would be much more generally distributed than at the present time. With the growth of population and the reclamation of the land, so noxious a creature would be bound to diminish in numbers, and finally disappear.

Although I have not myself seen the Adder nearer to Edinburgh than the centre of the Lammermoor Hills, where I killed two a number of years ago on the banks of the Whitadder,[2] near Johnscleugh, in East Lothian, there can be no doubt, as I shall presently show, that it still exists in a few localities at the foot of the Pentlands, and also towards the Moorfoot Hills. But its numbers must be very limited, for I have wandered a great deal all over that ground during the last thirty years without seeing the trace of one; and as the result of numerous inquiries on the subject, the following is all the information I have been able to obtain.

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[1] With the view of tracing the history of these Edinburgh snakes, I have, since the above article was put in type, sent a letter to the *Scotsman* on the subject, but without result, except to bring to light the occurrence of other two examples. On 22nd June, Mrs Tait, Broughton Point House, Broughton Road, informed me that a snake was seen on her lawn the previous day. At my suggestion Mr James Taylor, for whom snakes and other reptiles have more than an ordinary interest, at once went in search of the animal, and succeeded in capturing it. Mr Eagle Clarke has examined this specimen, and tells me it belongs to the same southern European race as the one obtained at Haymarket in July 1892. From Mr Taylor, I learn that a typical example of the Ringed Snake was captured in a garden in Inverleith Row in July 1893, and taken to him for identification.

[2] Originally the Whitewater, and therefore having no reference to the reptile. See the "Old Statistical Account," where the name is also spelt Whitatter.

As regards the eastern portion of the Pentlands, I have entirely failed to hear of a single example,—several keepers, with long experience of the ground, declaring they never knew of one being seen there. On the moors adjoining the western parts, however, I have been able to trace them on both sides of the range. Taking the north side first, Mr Thomas Gray, farmer, Braidwood, Temple, informs me that in his young days they were not uncommon in certain localities in the southern or moorland portion of Midcalder parish. Crosswoodhill Moss was a favourite habitat, and he well remembers his brother killing two at a shot there one sunny day in March sometime during the "forties." He also remembers two sheep being "stung or bitten at Harper-rig: "their heads swelled to an enormous extent; they both died." From Mr Campbell, Dalmeny Park, I have some interesting adder stories which were current in this locality about half a century ago. On one occasion, at Middlerig, above Kirknewton, a calf was said to have been bitten on the tongue, which "hung out of its mouth all black and swollen, and caused its death in a few days." Belief in "Adder-stones," Mr Campbell tells me, was common. These were said to be flat stones with a hole in the centre, through which the adders glided to take off their skins!

Coming down to a much more recent date, Mr James Gray, farmer, Harper-rig, writes me that the last he saw there was during the warm summer of 1887. Another, which was supposed to have caused the death of a valuable ram, was seen by one of the farm labourers the same year. In the same neighbourhood a third was killed in April 1887 on the farm of Harburnhead by Mr Hutson, then shepherd there, by whom many others had been seen on the same ground (a moss between Harburnhead and Cobbinshaw) during the previous twenty years; and Mr Dunbar, mole-catcher, Currie, tells me he saw one that was killed on the road near Crosswoodhill toll five or six years ago.

In the Bathgate district I have reason to believe adders were, at one time, not uncommon, but I have not heard of any recent occurrence there. Mr Maxwell Durham of Boghead, near Bathgate, tells me, that between thirty and forty years ago, his father, the late Mr Durham Weir, used to see them now and again when shooting on Barbauchlaw and other little moors in that neighbourhood. Seven young ones "that came out of the mouth of an adder, which he shot," are still, with the head of the old one, preserved in a bottle at Boghead. The belief in young adders seeking safety from danger in the stomachs of their mothers is, as most of you are no doubt aware, wide-spread; but, like the stories of toads embedded in the solid rocks, the fact (if it be one) has still to be proved.

On the south side of the Pentlands we know from Neill ("Gentle Shepherd," 1808 ed., p. 273) that the adder inhabited Harlaw Muir in the beginning of the present century. On the adjoining extensive moor of Auchincorth, with which I was very familiar twenty to thirty years ago, and have often visited since, I have been told it still exists, which I do not doubt, but its numbers must be very limited, for in the course of my many rambles over the ground I have never come across one dead or alive. A few miles nearer West Linton it has been noted by Mr T. G. Laidlaw, but very rarely, the only example he has actually seen being a dead one lying on the road near Coalyburn, about twenty years ago.

As the last-mentioned locality takes us into Peeblesshire, it may be well to note here what is recorded of the species in "Chambers's History" of that county. The Viper or Adder, we are there told, was then (1864) common; "but whilst it is comparatively plentiful in some places, in others it is never seen, whilst there is no apparent difference in the localities themselves. Thus, it is not unfrequent in some parts of the parish of Traquair, but is almost unknown on the northern side of the Tweed, in the parish of Innerleithen." Mr R. S. Anderson informs me that a large example was killed in the schoolhouse garden at Tweedsmuir in 1892, and that about five years ago a young one was caught among heather in Megget. The latter may, however, have been a Slow-worm.

In the parish of Temple, in the southern portion of Midlothian and towards the foot of the Moorfoot Hills, it would appear still to linger in one or two suitable spots. Mr James Low, schoolmaster, Temple, tells me that on 13th June 1879 (the day the Edinburgh Waterworks at Gladhouse were opened), he and a friend discovered two, an old one and a young one, the latter of which they killed, lying in the sun on a piece of moorland belonging to the farm of Yorkston; and Mr James Mitchell, Rosebery, writes that he knows of three others having been killed in the same quarter—one on Side Moor, one on Yorkston farm, and one on Mauldslie farm. These, he adds, were all true adders, from 20 inches to 2 feet long.

Throughout the greater part of the Lammermoors, adders are still fairly common. I have myself killed them on the shingle by the Whitadder, near Johnscleugh, and several informants have reported them from other parts of that hill-country. Mr James Caverhill, in an interesting letter on the subject, says,—"The country round about Crichness is full of 'Éthers.' They are to be met with everywhere, but most frequently in gullies where the heather is grown-up and exposed to the sun, and also on rocky brae-sides with a southern aspect." On a certain rocky face he could undertake to kill a dozen in a suitable day. Taking the country generally, a shepherd might kill twenty to thirty in a season. When he lived on the farm two or three sheep (out of a flock of about 3000) were "stung" each year, usually either on the udder or on the lip. A specimen (female) since received from Crichness measures 24½ inches, and weighs 4¾ oz. (134 grammes).

Dr Hardy, who has long been collecting information and anecdotes regarding the viper in the Border counties, which I hope we may soon see published in the *Proceedings of the Berwickshire Naturalists' Club*, writes me, under date 22nd February 1893, as follows:—"No East Lothian notes, except that at Caldra shepherd's house, at foot of Spartleton, adders are numerous, and the shepherd lost two of his dogs by being bitten. Occurs in Greywacke Crags, near the cottage, which is on Bothall farm. The Dye Water, apparently to near its head, as well as its tributaries, full of adders: have many notes. Two years ago I was at the 'Mutiny Stones' above Byrecleugh, and encountered an adder in the moss near the footpath leading to East Lothian, on other side of the ridge."[1] Mr Archibald Hepburn, formerly of Whittinghame Mains, East Lothian (now of Aldridge, near Walsall), informs me that in his time it "was very rarely seen in that part of the county, and such was the invariable report received from gamekeepers and other observers from the western boundary of the parish of Garvald, and along the lower and northern slopes of the Lammermoor Hills to Dunglass Dean by the sea." On two or three occasions a reptile, supposed to be an adder, was seen by members of his family basking by the side of the footpath on the north side of Presmennan Lake, but Mr Hepburn was never successful in seeing it himself. It seems to me this is more likely to have been a slow-worm than an adder.

As regards the north side of the Forth, I have no actual record for Fife, although I have been told that "Adders" used to be seen on a moor in the western part of the county (Moss Morran ?). In the detached portion of Perthshire immediately to the west of Fife, Mr J. J. Dalgleish informs me that many were killed in 1869, on a piece of moss of three or four acres which was being levelled and improved on his estate of Westgrange. Since then he has not heard of any being seen in that quarter.

In the more highland part of the valley beyond Stirling, they are still to be met with in many spots, but, except in a few localities, not plentifully. Mr Winter, keeper, Doune Lodge, tells me they are occasionally seen on that estate. He has a specimen of the ordinary type obtained there a year or two ago. Between Callander and Port o' Menteith, the moors round about Loch Rusky are a favourite habitat, where a few, I am informed, are killed every year. When staying at Callander a couple of years ago I had several other haunts in that neighbourhood indicated to me, and of course many strange stories of encounters with the reptiles are there current. A particularly ferocious one, which struck terror into the heart of my informant, was declared to whistle loudly, and to have a mane along its back! The only example of the reddish-brown variety I have been able to hear of was killed a few years ago in a ploughed field a mile or two from Callander.

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[1] I have to thank Dr Hardy for the following further information,—"On 3rd May 1894, a young adder was found in a field on Under Bolton, near Haddington, during turnip-making: it was about 15 inches long."

Class BATRACHIA.

Order ECAUDATA.

RANA TEMPORARIA, *L.* COMMON FROG.

The Frog is our most common and generally distributed Batrachian, being abundant almost everywhere from sea-level to the most upland localities, and appearing as much at home in a ditch or pool on the bleak moorlands of the western Pentlands as in a marsh in a genial spot by the shores of the Forth.

The spawn is usually deposited during the second or third week of March, shortly after the first warm days of spring have awakened the animals from their hibernation in the mud; but the time varies a little, of course, according to the nature of the season. This year, on 17th March, I observed a quantity on Pomathorn Moor, near Penicuik, frozen solid by the frost of the previous night—an experience which it often undergoes apparently without harm. If there be a number of Frogs in a pond it will be found that during the spawning season the bulk of them congregate at one spot. In this way many clusters of spawn are frequently to be seen joined together, forming a large continuous mass. One such mass which I measured in Drumshoreland Curling-Pond was roughly 8 yards long by 3 broad. The number of ova in a cluster deposited by a female in my aquarium was estimated at about 1400; but this number would appear to be much under the average, and is often greatly exceeded. Mr L. Greening states, in a paper read before the Warrington Field Club in November 1887, that he has counted from 1500 to 2500 in a cluster, and considers 2000 about the average. In France, however, M. Héron-Royer has found much larger numbers; he records 2856, 3337, and 4005 (*Bull. Soc. Zool. France*, iii., 1878, p. 122).[1]

At a season of the year, and in circumstances when so many creatures assume gayer tints and special ornamentation, I have often remarked the dingy and flabby appearance of the Frog, compared with his brighter colour and markings, and altogether more attractive aspect, when leading a more terrestrial life later in the year. I have also been struck by the suddenness with which they disappear for a time immediately after spawning. Visiting one of the ponds on the Braid Hills in the middle of March, numbers were to be seen—some of them in pairs; a few days later the spawn had been deposited, and many of the frogs themselves were still on the spot croaking loudly, but they appeared to be all males; in another week a single example was all that could be discovered.

The colour and markings of the Frog vary greatly; so does the size. It has long been known, as Mr Boulenger remarks in a recent number of *The Annals of Scottish Natural History*, 1893, p. 202, that the Common Frog grows to a large size in Scotland, and occasionally assumes so peculiar a physiognomy as to have been described as a distinct species, *Rana scotica*, by Bell. The *Rana esculenta*, of Don's list of Forfarshire Animals (Headrick's "Agriculture of Angus," 1813, Appendix, p. 45), is supposed to have been nothing more than this variety of the Common Frog; and in 1833 Dr Stark exhibited, at a meeting of the Zoological Society in London, a skeleton of this variety as that "of the Edible Frog, *Rana esculenta* (Linn.), and stated that the species is found in the neighbourhood of Edinburgh, whence his specimen was obtained." In the spring of 1848 Wolley supplied Professor

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[1] I am indebted to Mr Boulenger for this reference; also for drawing my attention to a number of other books and papers bearing on the life-histories of our Batrachians, among them being Rösel's Historia Naturalis Ranarum Nostratium, 1758, which contains the most beautiful coloured illustrations of the present species I have yet seen.

Bell with numerous specimens of both sexes, and of various ages, of the Scottish Frog from the Braid Hills, with the result that Bell became convinced "it is nothing more than a very large variety of the Common Frog, *R. temporaria*"—*vide* the second edition of his "British Reptiles," p. 108. In this finding subsequent herpetologists concur.

These large frogs are still to be found in the ponds and marshes on the Braid Hills and elsewhere in the neighbourhood of Edinburgh, where I have frequently observed them. In the spring of 1888 several, which were found clinging together under a stone at the bottom of the lower Braid pond, were turned into my garden, where they lived for a considerable time. They were unusually large examples, but unfortunately I neglected to measure them. A good idea, however, of the size to which frogs occasionally grow in Scotland is afforded by some measurements given by Mr Boulenger in his paper above alluded to (*Ann. Scot. Nat. Hist.*, 1893, p. 202): three specimens—two females and a male recently received by him from the North of Scotland, were 95, 93, and 80 mm. long respectively. The size of ordinary examples in our district may be gathered from the dimensions of four adult males and a female now before me; the males measure respectively 76, 71, 70, and 66 mm., and the female 80. In one of them the temporal spot, which serves as a specific character, may almost be said to be absent, so nearly does it correspond with the general ground colour. The usual length of the species, according to Bell, is 2 inches 8 lines = 68 mm., but Fatio puts the average size of the adult at 73 mm.

The following discovery of frog remains, made a few years ago in a very unexpected quarter, is perhaps worth mentioning. In December 1882, during the extensive alterations then being made on St Giles Cathedral, the workmen exposed a hole in the wall over one of the arches, in which were the shell of an owl's egg and a large quantity of bones—dry and old—chiefly those of small mammals and frogs, some of which I secured. The hole must have been plastered up for over half a century, and prior to that time it had evidently been tenanted for many years by Barn Owls, which no doubt found a plentiful supply of frogs about the margins of the Nor' Loch and the Borough Loch, or in the pools and ditches to which these were ultimately reduced. The Nor' Loch, which I need scarcely remind you lay in the hollow now occupied by the Waverley Station and Princes Street Gardens, was finally drained about the close of last century; the Borough Loch, which occupied the space now known as "The Meadows," followed thirty or forty years later.

[BUFO CALAMITA, *Laur.* NATTERJACK TOAD.

This species, whose only known Scottish habitats at the present day are on the shores of the Solway, is included in a list of Reptiles, etc., given in the "New Statistical Account" of the parish of Cockburnspath and Oldcambus, which was drawn up by the Rev. Andrew Baird in 1834. The sentence containing the statement is as follows:—"The *Lacerta agilis*, or nimble lizard, is occasionally seen in the sunny heaths, and the natter-jack (*Bufo rubetra*), we have seen one specimen of."

Until this record has been corroborated by the discovery of further examples in the district, I fear we must deny the species a full place on our list. Except in the south, its distribution in the British Isles is of a decidedly western type, and I much doubt if it occurs anywhere in the east of Scotland. Nevertheless a few small colonies may possibly exist, and all likely localities for them should be examined. The likely places are among the coast sandhills, or under stones near high-water mark. That the Natterjack once had a wide range in Scotland would seem probable from the fact that toad-remains found by Mr B. N. Peach in a cave in Assynt have been referred to this species.]

BUFO VULGARIS, *Laur.* COMMON TOAD.

The Toad, though not so numerous as the Frog, especially in the moorland districts, is well entitled to rank as one of our commoner animals. Being to a large extent nocturnal, it is apt to be regarded as less common than it really is. On a warm summer evening, after a copious fall of rain, and while everything is yet dripping with moisture, toads are often to be seen in considerable numbers flopping along the wet roads, more especially in woodland districts; but we must visit the ponds, etc., in which they spawn in spring, if we would form a proper estimate of their abundance—hundreds may then be seen in an old flooded quarry, for instance, not more than a few score yards in circumference.

In ordinary seasons the Toad spawns about the middle of April, that is, about three weeks later than the Frog. My dates (with the exception aftermentioned) extend from the 6th to the 27th, the last referring to an upland habitat near Balerno. No sooner have the frogs disappeared from view than the toads make their appearance in the ponds, and reproduce the busy scenes so lately enacted by their relatives. Visit one of our rural curling-ponds, say, on a bright day, about the middle of March, and you will find it alive with frogs; revisit it two to three weeks later and you will be interested to see that the croaking throng is now made up entirely of toads. The transposition is so complete, and the general appearance of the two animals while living in the water so much more alike than usual, that the casual observer is apt to overlook the change which has taken place. Unlike the frog, the toad looks its best during the short time it takes to the water in spring. The general colour is then brighter, and the markings more distinct. It seems also to prefer deeper water to spawn in than the frog; at any rate I have seldom observed it spawning in such shallow ditches and surface pools as the latter often resorts to.

As has just been said, the breeding-time of the Common Toad falls normally about the middle of April. It was, therefore, with no little astonishment that I found a pair in a deep pool in an old limestone quarry at Longniddry, East Lothian, in the very act of spawning so far on in the season as the 13th of June (1894). The couple were brought away and placed in my aquarium, where the remainder of the spawn was desposited. Several other males were swimming about in the pool (indeed it was their croaking that led me to the spot), and within about three yards of the first string of spawn was a second, apparently only newly completed. Hitherto the Common Toad and the Common Frog have been regarded as the two European types in which there is least individual divergence in the breeding-time. The discovery of the former spawning in June is, therefore, Mr Boulenger (to whom the specimens and some of the spawn have been sent) tells me, a matter of very considerable interest. The reason for the present divergence is difficult to explain. The locality is practically at sea-level, and in as genial a spot as almost anywhere in the Lothians. The fact, however, that the pool, owing to its position, is hidden entirely from the sun's rays, except for a short time in the early part of the day, may account to some extent for the aberration.

The spawn, as most of you are aware, instead of being deposited in a cluster like that of the Frog, takes the form of a double string of gelatinous beads festooned about the stems and branches of water-weeds. Bell says that these strings are from 3 to 4 feet in length. Those I have examined, however, have been much longer—one (in the double state) measured on 9th April 1893, in a deep pool near Aberdour, was about 9 feet in extent, and was estimated to contain fully 3000 ova. When newly deposited, the ova are of course closer together and the strings shorter than after they have been some time in the water. Mr L. Greening states that he has counted from 900 to 1300 eggs in a string, and considers 1100 about the average; this, however, would appear to be much under the mark. In France, M. Héron-Royer (*op. cit.*) has counted 4972, 6326, and 6840. From a spirit specimen of a female captured near Winchburgh on 2nd April last, before any spawn had been deposited, I have taken the ova and carefully counted all that were advanced enough to have been laid this year: the number is 1911. The two strings of ova obtained at Longniddry on 13th June have also been counted; one contained 3132, the other, 4152.

While collecting Newts last spring in a pond where toads were abundant, I was amused, on lifting my net out of the water, to see one clinging firmly to a knot which had been made on the end of it to cover a tear. So firmly did he cling that he allowed himself to be dangled in the air a considerable time before letting go his hold, and no sooner was the net replaced in the water than he swam up and clasped it again.

The lengths (snout to vent) of a few breeding specimens are as follows:—

Male, 64 mm.	Female, 73 mm.
,, 62 ,,	,, 71 ,,
,, 61 ,,	,, 69 ,,

Our Toads, however, appear to be small indeed as compared with Continental examples. Fatio mentions one (a female from Sicily) which had attained the enormous length of 153 mm. His averages are—male 80 mm., female 100 mm. The length of a large specimen, according to Bell, is 3 inches 5 lines=87 mm.

Order CAUDATA.

MOLGE CRISTATA (*Laur.*). WARTY NEWT.

In former days, when sedge-girt pools and marshes abounded in the district, Newts, or Asks, as all the species are here popularly called,[1] would in all probability be more numerous than now; and but for the construction of artificial ponds, quarries, etc., which has provided them with many fresh habitats in place of the old ones destroyed by drainage —they would doubtless have been much less common at the present day than they are. From Stark's "Picture of Edinburgh," sixth edition, 1834, we learn that "several species" were then to be found in ditches in the Queen's Park; but I fear they have, like the ditches, long ago disappeared; nor have I been able to find any in the lochs in the park, although I am told they have been seen in Duddingston within comparatively recent years. Lochend has also been searched in vain; and now that the greater part of the Braid

[1] The Lizard also goes by the name of Ask.

Hills has become public property, their disappearance from the ponds and marshes there also is probably only a question of time—already I miss them from the skating-pond next the road.

The present species—the Warty Newt—is fairly common throughout the lowland parts of the district, inhabiting weedy ponds, flooded quarries, and other stagnant pools of a more or less permanent character, for, unlike its smaller relatives—especially *M. palmata*—it is, according to my experience, seldom found in those shallow pools and ditches that dry up completely during summer.[1] It is also, I consider, a somewhat earlier breeder than the other two—this year, for instance, males and females in pairs, and with the nuptial dress fully developed, were numerous in the upper Braid Pond by the middle of March, and in an early spring I have no doubt they might even be seen in February. Newts, however, do not deposit their eggs all at once in clusters and strings like the frog and the toad, but singly or in twos and threes—one on this leaf, one on that; nor do they begin to spawn in the simultaneous manner which characterises their ecaudate relatives, the combined effect being the prolongation of the breeding season for several weeks or even months.

The following list of habitats from which, with but one or two exceptions, I have recently examined specimens of *M. cristata*, will serve to indicate the extent of its present distribution. Where I have been indebted to others for the specimens, the name of the sender is given after that of the record; and, unless otherwise stated, the date given refers to the present year, 1894:—

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[1] I have long suspected that many of our Warty Newts must pass the winter in the mud under water. According to Fatio such is the case, and the habit, it would seem, is not confined to the present species. "Les adultes de cette espèce," he says, "paraissent plus exclusivement aquatiques qu'aucun autre de nos Tritons; quelques-uns n'abandonnent les mares que passé le milieu de l'été ou seulement en automne, d'autres restent même dans l'eau durant toute l'année." . . . "A l'approche des frimas, et à une époque variable avec les circonstances, nos Tritons à crête deviennent plus lourds et s'enfouissent alors, la plupart dans la vase au fond des eaux, quelques-uns, les jeunes surtout et parfois des femelles, sous la mousse, dans une fissure du sol, ou encore sous l'écorce d'un arbre. Enfin, nous avons vu que l'engourdissement hivernal est, en general, assez peu profond" (Vert. Suisse, iii., p. 531; see also pp. 570 and 581, where the habit is referred to in the case of the next two species).

Ponds on the Braid Hills, on many occasions during last thirty years, adults abundant from March to July or later. In my experience the females disappear first. Pond at The Bush, near Rosslyn, adults in full nuptial dress, common, 28th March, fine male, 29th June; horse-pond between Rosslyn and Auchindinny, adult male, 23rd July 1893; pond and old quarry near Penicuik, a number of years ago, common; Drumshoreland Curling-Pond, adults, 30th March; cattle-pond, Duntarvie near Winchburgh, and flooded quarry a little nearer Hopetoun, a few adults, April 1893 and April 1894; pond at the Craigs farm, Midcalder, large male, 7th April (C. Campbell); curling-pond, King's Park, Stirling, adults, 4th and 20th April (Messrs Kidston and M'Lellan); near Callander, April (H. Miller, jun.); old quarry near Burntisland, a few years ago; quarry-hole near Prestonpans; horse-pond near East Linton, a number of years ago; pond near Dunbar, adults common, 14th April (G. Pow); etc.

The *Zoologist* for April 1894 contains a paper by Mr Boulenger "On the Size of the British Newts," in which he gives the dimensions of the largest specimens examined by himself or recorded by other observers. In respect of *M. cristata*, he gives the following measurements:—

Male from Hampton, Middlesex,—total length	144	mm.,	to cloaca	77.
Female „ „ „	162	„	„	87.
Male from Argenton, France, „	142	„	„	72.
Female „ „ „	157	„	„	76.

The female from Hampton, which appears to be the largest on record, had thus attained the length of 6⅜ inches.

The largest examples I have examined were sent to me from Dunbar in April last by Mr G. Pow, and measured as follows:—

Male,—total length	145	mm.,	to cloaca	75.
Female, „	156	„	„	79.

These figures are much above the average, however, as will be seen from the following further measurements of specimens taken very much at random, but apparently all adult.

Male,—	total length	140	mm.,	to cloaca	71.
,,	,,	138	,,	,,	73.
,,	,,	135	,,	,,	69.
,,	,,	137	,,	,,	74.
,,	,,	137	,,	,,	73.
,,	,,	133	,,	,,	68.
,,	,,	132	,,	,,	69.
,,	,,	132	,,	,,	—
,,	,,	131	,,	,,	70.
,,	,,	127	,,	,,	67.
,,	,,	124	,,	,,	—
,,	,,	123	,,	,,	—
,,	,,	121	,,	,,	64.
,,	,,	117	,,	,,	—
,,	,,	114	,,	,,	63.
,,	,,	113	,,	,,	60.
Female,	,,	143	,,	,,	73.
,,	,,	139	,,	,,	—
,,	,,	137	,,	,,	71.
,,	,,	132	,,	,,	—
,,	,,	129	,,	,,	—
,,	,,	126	,,	,,	66.

[illegible] a few examples weighed, I give the results, [illegible] of little value in the absence of other [illegible] the specimens:—three males, 10·675, [illegible] respectively; three females, 9·4, 8·7, [illegible] Cooke, quoting from Higginbottom's [illegible] 134 grains (8·7 grammes) as the average [illegible] at the end of the fourth year.

[illegible] VULGARIS (*Linn.*). SMOOTH NEWT.

[illegible] the *Lissotriton punctatus* of Bell's [illegible] occupies in the district much the same [illegible] the two very frequently occurring in [illegible] pool. The present is, however, in my [illegible] the more abundant. I have often, [illegible] Braid marshes, and on warm [illegible] in more recent years, have [illegible] habitats—and admired it too, [illegible] season is really a handsome creature. A few days of genial weather in March, or even earlier if the spring be a particularly early one, usually has the effect of recalling it to activity, and causing it to reappear in the water. On their first appearance the males are only partially in nuptial dress, but the crest and colours rapidly attain their full development. During the whole of April, May, and June I have observed spawning females accompanied by richly spotted and crested partners, and in some seasons they may no doubt be found up to a still later date.

The following list of localities, mostly verified this year by the examination of specimens, while perhaps of little value at the present moment, is given in the hope that it may prove of interest at some future time.

Ponds on different parts of the Braid Hills, common from March onwards; on 21st March the males seen had not acquired full breeding dress; on 9th April several captured had it fully developed, and most of the females seemed full of spawn; on same day a few of last year's larvæ, which lost their external gills three weeks later, were obtained. Weedy pool at Blackford Quarry, several, April 1893; pond at The Bush, near Rosslyn, adult males and females abundant 28th March, males 29th June; horse-pond, Duntarvie Castle, near Winchburgh, adult female, 2nd April; curling-pond, King's Park, Stirling, a few males and females, 2nd and 20th April (Messrs Kidston and M'Lellan); near Dalhousie, female, June 1887; Luffness Curling-Pond, males and females, many occasions in spring and early summer during the last ten or twelve years—two fine females still spawning on 1st June 1894; Gullane Quarry, and sandpit on the Links near Jova's Neuk, a number of beautiful males and females in pairs, and some small ones under stones lying near the water, 12th June—in the same spot adult and half-grown examples were common under stones last September; near North Berwick, several specimens, some not full grown, beginning of April (Dr Crombie). I have also seen the species a number of years ago near East Linton, near Burntisland, and also near Penicuik; and Mr Hugh Miller, jun., tells me he obtained one in a pool at the side of Glencorse [illegible]ir on 2nd May 1893.

The largest specimens of *M. vulgaris* known to Mr Boulenger, and recorded in his paper already referred to (p. 517), are—

Male from Knockholt, Kent,—total length 104 mm., to cloaca 45.
Female ,, ,, ,, 94 ,, ,, 46.

The largest examples I have examined were taken at Luffness, East Lothian, in the beginning of the present month (June 1894). Their measurements, immediately on being taken from the water, were—

Male,—total length 97 mm., to cloaca 42.
Female, ,, 97 ,, ,, 46.

I ought to say, however, that the female, after being in a box for a day or two without water, was sent to Mr Boulenger, who made its length to be only 93 mm. The difference must have been due to shrinkage, for I feel sure there was no mistake in my measurement, which was repeated two or three times. The male is in my aquarium, and still fulfils the original dimensions as given above.

The measurements of a number of other examples which have passed through my hands recently are as under:—

Male,	—total	93	mm.,	to cloaca	42.	Female,	—total	94	mm.,	to cloaca	43.
,,	,,	92	,,	,,	40.	,,	,,	92	,,	,,	45.
,,	,,	91	,,	,,	42.	,,	,,	91	,,	,,	42.
,,	,,	90	,,	,,	—	,,	,,	90	,,	,,	41.
,,	,,	90	,,	,,	—	,,	,,	89	,,	,,	—
,,	,,	89	,,	,,	40.	,,	,,	88	,,	,,	—
,,	,,	89	,,	,,	39.	,,	,,	87	,,	,,	40.
,,	,,	88	,,	,,	42.	,,	,,	87	,,	,,	40.
,,	,,	88	,,	,,	37.	,,	,,	87	,,	,,	—
,,	,,	87	,,	,,	—	,,	,,	86	,,	,,	41.
,,	,,	86	,,	,,	—	,,	,,	83	,,	,,	—
,,	,,	85	,,	,,	37.	,,	,,	83	,,	,,	39.
,,	,,	84	,,	,,	39.	,,	,,	81	,,	,,	—
,,	,,	84	,,	,,	38.	,,	,,	81	,,	,,	38.
,,	,,	82	,,	,,	—	,,	,,	80	,,	,,	37.
,,	,,	82	,,	,,	35.	,,	,,	79	,,	,,	—
,,	,,	81	,,	,,	37.	,,	,,	79	,,	,,	39.
,,	,,	80	,,	,,	34.	,,	,,	78	,,	,,	—
,,	,,	79	,,	,,	36.	,,	,,	76	,,	,,	37.
,,	,,	76	,,	,,	—	,,	,,	73	,,	,,	36.

The averages, including the two previously mentioned, are—

Males,—total 86·3 mm., to cloaca 38·7.
Females, ,, 85·3 ,, ,, 40·3.

The weights of a few examples are—

Males,—2·15, 2·07, 1·75, and 1·75 grammes.
Females,—3·48, 2·8, 2·75, 2·32, 2·18, and 1·58 grammes.

Three hundred and twenty-six ripe ova were taken from one female.

MOLGE PALMATA (*Schneid.*). PALMATED NEWT.

It is now close on half a century since John Wolley, the well-known ornithologist, found this Newt in abundance in the neighbourhood of Edinburgh, and by his note in the *Zoologist* was the means of the species being for the first time clearly recognised as a native of Britain. This was in 1848.

Wolley's communication to the *Zoologist* (p. 2149) is so interesting, and sets forth the salient characters of the adult male in spring so clearly, that I do not hesitate to quote it in full. It runs thus: "A kind of Newt occurs in ponds and ditches about Edinburgh which I have not observed elsewhere. The males are remarkable for a ridge on each side of their back, which gives it great breadth and squareness, for their wholly-webbed feet, and for the mode in which their tail terminates: it appears as if the tip had been nipped off, the central filament of it only remaining, and projecting for a quarter of an inch. In colour and style of marking it differs considerably from Lissotriton punctatus of Bell. The females are less easy to recognise. There appear to be characteristic differences in the bones of the two species, at least in the vertebræ and the skull, also in the general proportions of the head, body, and tail. The males do not vary much from one another: I have examined upwards of one hundred of them, but as yet only in their spring appearance. The webs of the feet, the caudal filament, the crests, and the dorsal ridges are probably absorbed later in the year, as I judge from the degrees of development I have already seen, and especially from a Newt of this kind I found in the bed of a pool which had been dried up some days before. It occurs in company with L. punctatus, but in one ditch I found it alone and in plenty, from which I have been able satisfactorily to ascertain the females. A more full account will, I hope, before long be furnished by Mr Bell, who had specimens of the same, or a similar Newt, sent to him from Devonshire several years ago. It seems to occur generally round Edinburgh, as far as my walks extend. Yesterday (May 1st) I saw this, and no other species, during a ramble in the Pentland Hills."

From Wolley's description the editor of the *Zoologist*—the late Edward Newman—and M. Julian Deby had no difficulty in recognising the Newt as the true *palmipes* or *palmata* of Continental authors.

In the autumn of the same year Wolley discovered the species in the north of Sutherland, thus indicating for it a very wide range in the country. Since then it has been recorded from other localities, both north and south, but its Scottish distribution is still very imperfectly known—the whole of the records being easily counted on one's fingers.

In the Edinburgh district I find it more widely distributed than either of the other species; and, being abundant where it occurs, it is to be regarded as the most common of the three. On the plains and less elevated parts of the district, all three are often to be found in the same pond; but on the more upland parts the present one is, in my experience, alone to be met with.

Within the last two or three years I have been at considerable trouble to ascertain the extent of its distribution in the district, and I have been able to satisfy myself that it is both generally dispersed and abundant. On our moorlands it would appear, from Wolley's remarks, to have been even more numerous in his time than now, which is not to be wondered at, in view of the extent to which these wilds have been dried by drainage in the interval.

The following list of localities, from which I have recently (1894 unless otherwise stated) critically examined many examples, will serve to show how widely it is dispersed:—Bavelaw Moss, near Balerno, in pools, April 1889 and May 1894, only species observed; Loganlee, in ditch, May 1888, only species present; The Bush, near Rosslyn, in weedy pond, along with the two previous species, 28th March, adults common, and many of last year's larvæ—some spawn deposited as early as 4th April by a female placed in my aquarium; pond on top of the Braid Hills, adult male, 26th May—all three species present (Mr H. Miller, jun.)—in the same pond and in a small marsh recently drained, in the hollow on the Mortonhall side of the hills, I have seen it in former years; near Davidson's Mains, in marl pit, 22nd March, only species seen; Corstorphine Hill, a male—with tail filament and webs of hind feet only partially developed—under a stone in dry quarry, 6th April; Dalmeny Park, in old quarry, April and May 1893 and 1894, common, and only species obtained (Messrs Bruce and Charles Campbell); Drumshoreland, in curling-pond, 30th March, common, along with the other two species; Polkemmet Moor, near Bathgate, in peat-holes, May 1888, only species present; Spittalhaugh, near West Linton, in red sandstone quarry, 31st March, only species observed (D. G. Laidlaw); Stobo, Peeblesshire, in skating-pond, April, only species obtained (John Thomson); Broughton, an adult male, 27th April; Tweedsmuir, four adult females, 2nd June; and Kingsmeadows Road, near Peebles, at foot of wall, 20th April, numerous immature examples, mostly quite young, and evidently just emerged from tadpole state (R. S. Anderson); near Longniddry, in limestone quarry, 6th April, common, and only species present (W. Saunders); Do., 13th June, adults still numerous and breeding; Broomhall, near Dunfermline, 14th May, two adult males in pond, and several immature examples under stones (W. Lumley); near Kilconquhar, in moist spot under rushes, August 1893; Boarhills Curling-Pond, near St Andrews, 16th April, common, and only species seen, some still in larval state (W. Berwick); Do., 5th June, a number of adults (J. R. W. Cook); Tayfield, near Newport, an adult male, 14th May (W. Berry); Brankston Grange, by Alloa, 23rd April, only species obtained (J. J. Dalgleish); near top of hill behind Callander, one under stone, April 1892; Callander, in pond at Hydropathic and in ditch on moor to the south, 9th and 14th May; near Quarter House, Stirlingshire, 30th April, many (J. A. Harvie-Brown); deep pool (old sand-hole) on Luffness Links, 1st June, two unusually large larvæ. I have also seen it in former years in a number of other localities—Penicuik, Macbiehill, Gladsmuir, etc.

By March, if the weather be genial, the Palmated Newt, like its congeners, will be found to have reappeared in many of the shallow ponds, stagnant pools, and ditches which it frequents during the breeding-season, but the time of their appearance (and disappearance) depends greatly on the nature of the season, and the character of the habitat. For instance, in a dry spring I have looked for them in vain in certain localities till a copious fall of rain, towards the end of May, filled the ditches, in which they breed. The nuptial dress of the males soon attains its maximum development, and by April many of the females will have begun to deposit their spawn. Adult males in spring are easily recognised, and after a little practice the females also can be separated from *M. vulgaris* at a glance—the colour of the belly, which seldom has the deep yellow or orange tint seen in the other species, and is less spotted, I generally find to be a safe and ready guide.[1]

Except in ponds fed by springs, I have seldom observed them in the water after May or June, their other habitats (often mere ditches) being, by that time, either wholly dry or greatly reduced in area. When this takes place they may be found under stones about the spot, or conveniently near; but a fresh fall of rain, by refilling the ditches, and raising the level of the ponds, is often the means of causing them to reappear in the water. Many of the larvæ remain over the winter in that state, and in spring are to be seen in the water simultaneously with the adults assembled for another breeding-season. Their length is then about 35 to 40 millimetres. Mr R. S. Anderson, road surveyor, Peebles, tells me that his workmen turn up newts in hundreds when clearing away the grass at foot of walls on roadsides; and that in October and early in November they are found in great numbers among road metal—especially such as has been lying for a few years in heaps—when the men are lifting it for spreading on the roads. A dozen sent me from the roadsides in April were all young examples of the present species, measuring from 36 to 57 millimetres in length. The smaller ones had evidently just left the water. Occasionally, however, a few of the larvæ appear to remain in the branchiate state long after the usual term. As already mentioned, two such were found in a deep pool on Luffness Links on 1st June 1894. "It is a pity," writes Mr Boulenger, to whom one of them was sent for determination, "that you did not keep it alive, as it might have grown still and ripened its sexual organs whilst retaining its gills, thus reproducing the condition of the Axolotl, as is known to happen in *M. cristata*, *M. alpestris*, and *M. vulgaris*." The length of this specimen was 52 mm.

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[1] An excellent description of the Palmated Newt will be found in Fatio's Faune des Vertébrés de la Suisse, vol. iii., where there is also a very fair coloured illustration. Leydig's Molche der wurttembergischen Fauna, 1867, in which enlarged figures of the characteristic parts of this and the preceding species are given, may also be consulted with advantage.

During March, April, and May of the present year, when large numbers were passing through my hands, I took the measurements of fifty males and fifty females, all supposed to be adult. Their total lengths in millimetres were as under:—

Males.		
1	measured	83 mm.[1]
1	,,	82 ,,
2	,,	81 ,,
2	,,	80 ,,
4	,,	78 ,,
6	,,	77 ,,
7	,,	76 ,,
4	,,	75 ,,
6	,,	74 ,,
7	,,	73 ,,
6	,,	72 ,,
2	,,	71 ,,
1	,,	69 ,,
1	,,	68 ,,
Average,		75·2 ,,

Females.		
1	measured	88 mm.
1	,,	86 ,,
1	,,	85 ,,
4	,,	84 ,,
6	,,	83 ,,
5	,,	82 ,,
6	,,	81 ,,
8	,,	80 ,,
2	,,	79 ,,
3	,,	78 ,,
1	,,	77 ,,
2	,,	76 ,,
3	,,	75 ,,
2	,,	74 ,,
3	,,	73 ,,
1	,,	72 ,,
1	,,	71 ,,
Average,		79·7 ,,

These measurements include, in the case of the males, the caudal filament, which, on the average, would not be more than about 3 mm.—6 mm. is the longest I have made a note of.

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[1] 79 mm. excluding caudal filament.

The length to the anal eminence (cloaca) was not taken in every instance, but, as far as noted, the results were as follows:—

Males.		
3	measured	38 mm.
3	,,	37 ,,
9	,,	36 ,,
8	,,	35 ,,
4	,,	34 ,,
4	,,	33 ,,
1	,,	32 ,,
Average,		35·3 ,,

Females.		
1	measured	45 mm.
4	,,	42 ,,
2	,,	41 ,,
8	,,	40 ,,
6	,,	39 ,,
8	,,	38 ,,
6	,,	37 ,,
4	,,	36 ,,
2	,,	35 ,,
Average,		38·8 ,,

In Mr Boulenger's paper "On the Size of the British Newts" (*Zoologist* for 1894, p. 145), the largest dimensions given are—

Male from Geneva,—total length 86 mm., to cloaca 37 mm.
Female from Cornwall, ,, 85 ,, ,, 42 ,,

My largest specimens are—

Male from Longniddry,—total length 83 mm., to cloaca 38 mm.
Female ,, ,, 88 ,, ,, 45 ,,

Mr Boulenger has seen this female, and confirmed my measurements. It is therefore the largest *M. palmata* yet placed on record, and has been presented to the British Museum.

The weight of the female just mentioned was 3·45 grammes. Other weights, most of which have been kindly supplied to me by Mr Eagle Clarke, are as follows:—

Male, 2·15 grammes.	Female, 2·39 grammes.
,, 2·00 ,,	,, 2·30 ,,
,, 1·81 ,,	,, 2·30 ,,
,, 1·55 ,,	,, 2·18 ,,
,, 1·50 ,,	,, 2·10 ,,
,, 1·48 ,,	,, 2·05 ,,

A female taken early in the season, before it had commenced to spawn, contained 292 ripe ova; another contained 437.

XXXIV. *A List of Spiders* (Araneidea) *collected in the Neighbourhood of Edinburgh.* By George H. Carpenter, B.Sc., and William Evans, F.R.S.E. [Plate XII.]

(Read 19th April 1893; revised for publication to 20th June 1894.)

[*Introductory Note by W. Evans.*—The idea of collecting material for a list of the Spiders of the Edinburgh district first occurred to me in the summer of 1888. While pursuing other branches of natural history, my attention had often been arrested by the great variety and interesting ways of these much-despised creatures; and in due time there came the desire to know their names, and something more of their habits and economy. Books and other sources of information were thereupon consulted, and through them the fact was soon revealed that the Spider-fauna of the country around Edinburgh had practically never been investigated—the Rev. O. Pickard Cambridge's four or five days' visit in 1861 being apparently all that had been done in this direction. Indeed, as a field for arachnological research, the greater part of Scotland was, and still is, almost virgin soil.

Here, then, was opportunity for useful observations which might very well be carried on simultaneously with other field-work without much additional labour. Accordingly, during the summer of 1888, as already indicated, I began collecting Spiders, and have continued doing so at intervals ever since. The naming of them, however, was a much more serious matter; and, after mastering some thirty or forty of the more conspicuous species, it became plain that the determination of any considerable part of the others would require much more time and study than I was able to give to the subject. The aid—and a large amount of that, too—of some one well versed in this particular branch of zoology was indispensable if further progress was to be made; and it was, therefore, a source of much satisfaction to me to learn that Mr G. H. Carpenter, of the Science and Art Museum, Dublin, was willing to go over my specimens, and name them for me. I cannot sufficiently express my indebtedness to Mr Carpenter for the great trouble he has taken in so thoroughly examining and reporting on the large number of specimens from time to time sent to him, and for the knowledge of Arachnids I have thus gained at his hands. Another page in Nature's book has been unsealed for me, and woodland, meadow, moor, and mountain thereby invested with a new interest.

In the work of collecting specimens for the present list, I have to acknowledge, outside my own family, only the assistance of Messrs Bruce and Charles Campbell, who have kindly procured for me a few tubefuls from Dalmeny Park.]

The collection of Spiders upon which the following list is almost entirely founded, has been made mainly within a radius of ten miles of the city, but it must not be supposed that the various sections of this area have received equal attention. Naturally, the localities most thoroughly examined have been those nearest at hand; and, as a matter of fact, the bulk of the collecting has been done within a radius of six or seven miles. Beyond the ten mile radius, practically only two localities have been examined, namely, Aberlady, some four or five miles farther east on the Haddingtonshire coast, and the neighbourhood of Leven on the opposite coast of Fife. The results of a few hours' collecting on the Isle of May, at the mouth of the Firth of Forth, and at Bridge of Allan near Stirling, have also been incorporated, though both places are a good deal farther off than any of the others mentioned in the paper.

Looking to the character of the district, regarded in the restricted sense above indicated, and the length of time it has been under cultivation, a rich Spider-fauna was perhaps scarcely to be expected. *Ceteris paribus*, Spiders, like the majority of other orders of creatures, abound most in districts least altered by the agency of man. But, perhaps, of not less importance than the absence of the implements of agriculture and of other industries, are warmth and sunshine, in respect of which Edinburgh, with its prevalence of cold east winds during spring and early summer, and frequent sunless days, does not compare well even with much of the rest of Scotland, to say nothing of the bulk of England.

Although the country around Edinburgh has long been so largely under tillage and pasture, we have still left to us—not in the bleak uplands alone, but even in the warmer districts near the sea, and well sheltered by plantations—a few bits of unreclaimed land, where golden furze or purple heather flourish with all the luxuriance we are accustomed to associate with less "improved" areas. Then, dells with wooded banks and open sunny spaces are almost a feature in the district; and we have, of course, the lovely gardens and pleasure-grounds attached to the mansions of the nobility. Marshy spots, and rush- and reed-fringed lochs—though far less numerous than formerly—are scattered around, and coast sandhills are not wanting. Nor must we forget the Pentlands, rising as they do to a height of close on 2000 feet above sea-level, and the other hills in the vicinity. The fact that here the mountains abut upon the east-coast plain would lead us to expect a mingling of the older alpine fauna with some of the newer immigrants which characterise eastern and south-eastern Britain.

It will thus be seen that, in spite of plough and east wind, a large proportion of the Spiders inhabiting Scotland may be expected to occur in the Edinburgh district, more especially when regarded in the larger sense in which the term is now generally employed, namely, as the area falling within a radius of twenty to thirty miles of the city. But while we believe the district will, in the matter of species, hold its own with most other Scottish areas of like extent, there can be little doubt that, as regards individuals, it will not take a very high place. Experience gained in Strathspey and some other parts of the Highlands seems to render this view highly probable.

Of previous research in the district we know of none save what the Rev. O. Pickard-Cambridge was able to accomplish in the course of a few days' visit to Edinburgh in June 1861. His observations, made almost entirely during three excursions to Arthur's Seat, and one to the Pentlands above Currie, will be found in an interesting paper entitled "Sketch of an Arachnological Tour in Scotland in 1861; with a List of Scotch Spiders," which was communicated to *The*

Zoologist the following year. His captures will also be found recorded in a subsequent paper by him, "On the Spiders of Scotland; with a List of Species," published in *The Entomologist* for 1877. The number of species in these lists having Edinburgh localities assigned to them is about thirty.

In the present list we are able to include one hundred and seventy-five species, all of which, excepting four, are represented by specimens in the collection now being reported on. The four which we have not yet ourselves seen from the district, are recorded by the Rev. O. P. Cambridge, so that their right to a place in the list rests on the best of authorities. In our gatherings there are also a number of doubtful females—besides many immature examples of both sexes—belonging chiefly to the Blackwallian genera *Neriene* and *Walckenaëra*, among which there are, doubtless, representatives of several additional species; but for the present we must pass these over, as Mr Cambridge, in whose hands most of them have been placed, cannot as yet say anything certain about them.

That Scotland possesses many species not yet recorded from north of the Border, is well illustrated by the fact that our present efforts have added no less than twenty-seven to the Scottish list, namely—*Dysdera cambridgii*, Thor., *Clubiona subtilis*, L. K., *Agroeca gracilipes* (Bl.), *Dictyna arenicola*, Cb., *Amaurobius ferox* (Wlk.), *Hahnia elegans* (Bl.), *H. nava* (Bl.), *Crustulina guttata* (Wid.), *Porrhomma egeria*, Sim., *Tmeticus huthwaiti* (Cb.), *T. expertus* (Cb.), *T. reprobus* (Cb.), *T. carpenteri*, Cb., *Microneta innotabilis* (Cb.), *Sintula diluta* (Cb.), *Gongylidium morum*, Cb., *Typhocrestus digitatus* (Cb.), *Araeoncus crassiceps* (Westr.), *Troxochrus hiemalis* (Bl.), *Lophocarenum parallelum* (Bl.), *Cnephalocotes curtus*, Sim., *Plæsiocrærus alpinus* (Cb.), *Tapinocyba mitis* (Cb.), *Caledonia evansii*, Cb., *Prosopotheca monoceros* (Wid.), *Maso sunderallii* (Westr.), and *Oxyptila simplex*, Cb. Of *Porrhomma egeria*, *Typhocrestus digitatus*, *Cnephalocotes curtus*, and *Plæsiocrærus alpinus* it has further to be remarked that the records are the first for Britain. But it is to *Dictyna arenicola*, *Tmeticus carpenteri*, *Gongylidium morum*, and *Caledonia evansii* that we would specially direct attention, these being new to science. The first is described by Mr Cambridge in an Appendix to the present paper, the second in the current volume (xv.) of *Proceedings Dors. Nat. Hist. and Antiq. Field Club*, and the other two in the *Annals of Scot. Nat. Hist.* for January last.

Taking Mr Cambridge's Scottish list (*Entomologist* for 1877) as a basis,[1] and adding the additional records contained in his "Spiders of Dorset," and in Mr H. C. Young's communications to the *Proceedings of the Glasgow Natural History Society* (vols. iii. and iv.), also those contained in the present paper, and one or two others, we find that the number of species known to inhabit the northern kingdom is slightly over 250—equal to about 48 per cent. of the 530 or thereby on the British list at the present time. We may be sure this is nothing like the total spider fauna of North Britain, but how far it falls short of that total it is, of course, impossible to say. Some light, however, may perhaps be thrown on the point by a statement of the proportions which Scottish lists bear to the British ones in other branches of invertebrate zoology. The three terrestrial groups of invertebrata which have attracted most attention in Scotland are Lepidoptera, Coleoptera, and land Mollusca. Unfortunately no general list of Scottish Micro-lepidoptera has yet been published, and local lists are few and mostly very incomplete: the figures we cite apply, therefore, to the "Macros" only. It is worthy of note, however, that the late Sir Thomas Moncreiffe, who collected Micros with as much zeal as Macros, records 309 of the former against 294 of the latter for the locality he specially worked, namely, Moncreiffe, near Perth; and he expressed the opinion that many micros still remain to be added to the list (*Scot. Nat.*, vols. iv. and v.).

According to South's "Synonymic List" (1884) the number of British Macro-lepidoptera is 817, of which 494, or fully 60 per cent., are entered in Dr Buchanan White's "Lepidoptera of Scotland" (*Scot. Nat.*, vols. i.-v.). The number of beetles described in Fowler's recent work ("British

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[1] Species entered therein solely on the strength of Northumberland habitats are excluded for the purposes of the present inquiry.

Coleoptera") is 3287, of which about 1840, or 56 per cent, are enumerated in Dr Sharp's Scottish list (*Scot. Nat.*, i.-vi.), including the additions by Messrs Lennon and Douglas recently published in the *Annals of Scottish Natural History*. Of the 129 Land and Fresh-water Mollusca given in the Conchological Society's latest list, 105, or 81 per cent., are known to occur in Scotland (Roebuck's "Census," etc.).

From the above it appears that a much larger proportion of Lepidoptera and Coleoptera fail to reach Scottish territory than is the case with the terrestrial mollusca. Now, in the matter of distribution, the spiders, we take it, are more likely to be in agreement with the insects than with the molluscs. On this basis we may venture to predict that the number of Scottish Araneidea is not less than from 320 to 345, that is, from 60 to 65 per cent. of the British species; and seeing 60 per cent. or thereby of the known Scottish Macro-lepidoptera have been taken in the vicinity of Edinburgh, there can be little doubt that when the district has been equally well worked for spiders the list will rise to considerably over 200 species.

The only Scottish districts for which anything like adequate lists of spiders have been hitherto published are the north-east corner of Berwickshire, in which Dr Hardy of Oldcambus has laboured;[1] and "Dee," which has been investigated by Professor Trail of Aberdeen.[2] The number of species (after allowing for some slight adjustments) recorded for Berwickshire is 116, and for "Dee" 115, as against the 175 now recorded for Edinburgh.

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[1] List of Araneidea and Phalangidea collected . . . in Berwickshire and Northumberland by Mr James Hardy. Rev. O. P. Cambridge, Proc. Berw. Nat. Hist. Club, vii., 307.

[2] List of Araneidæ (Spiders) of Dee. Prof. J. W. H. Trail, Trans. Nat. Hist. Soc. Aberd. (1878), p. 48.

The following analysis of the British, Scotch, and three local lists may perhaps not be devoid of interest:—

Family.	Great Britain and Ireland.	Scotland.	Edinburgh.	Berwick-shire.	Dee.
Theraphosidæ, . . .	3	0	0	0	0
Dysderidæ, . .	7	4	4	3	3
Drassidæ, . .	56	28	19	15	12
Agelenidæ, . .	22	10	7	4	4
Eresidæ, . . .	1	0	0	0	0
Dictynidæ, . .	15	5	5	2	2
Scytodidæ, . .	1	0	0	0	0
Pholcidæ, . .	1	0	0	0	0
Theridiidæ, . .	278	137	108	67	53
Uloboridæ, . .	2	0	0	0	0
Epeiridæ, . .	32	19	9	9	13
Thomisidæ, . .	43	16	7	7	7
Oxyopidæ, . .	1	0	0	0	0
Lycosidæ, . .	35	25	12	6	17
Attidæ, . . .	35	10	4	3	4
Totals, . .	532	254	175	116	115

The *Theridiidæ* (the "Micros" among Spiders) are, it will be noticed, by far the most numerous family in all the areas, being relatively highest, however, in the Edinburgh list, where they represent nearly 62 per cent. of the total species recorded for the district, as against 54 per cent. in the Scottish column, and 52 in the British. In Dorsetshire (the only county in these Islands which has been at all exhaustively worked) the proportion, according to the analysis at the end of the "Spiders of Dorset," is still less, namely, 50 per cent. This would seem to favour the view expressed by Mr Cambridge nearly twenty years ago (*Proc. Berw. Nat. Club*, vii., 307), to the effect that in all probability these minute species proportionally increase in numbers as we advance northwards. The difference, however, is probably not so marked as was then supposed. While we may look to the Theridiids for most of the future additions to our list, several other groups, especially the Drassids and the Lycosids, are sure to yield a number of interesting desiderata.

The absence from the present list of certain common species known to range from the South of England to the

North of Scotland will doubtless strike those of our readers who have given any attention to the group. *Epeira cornuta*, Cl., and *E. quadrata*, Cl., for instance, are absent, but the fact cannot well be attributed to mere want of observation, for we could scarcely have failed to detect such large and conspicuous spiders had they been present in any numbers. When the more distant parts of the district have been investigated, both species will probably be met with,[1] since they are known to occur in adjoining areas; but in the more immediate neighbourhood of Edinburgh their existence is doubtful.

This leads us to remark that in attempting to give the local status—common, rare, and so on—of each species, we state no more than our own experience, which of course is liable to be modified by further investigation. The extent of our data—based on something like four thousand specimens (the contents of over two hundred tubes, representing the captures of nearly as many days, made in all sorts of localities)—induces us, however, to believe that most of these statements will be found to be fairly accurate, and renders it highly improbable that any species really common has been overlooked.

In the majority of cases we have thought it desirable to give a list of the localities in which we have taken the species, however common, adding (and this is the essential part) the month, sex, and condition of the specimens—whether adult, immature, or very young—in the hope of throwing some light on their life-histories, a branch of the subject which has not yet received the attention it deserves. The yearly cycle of a number of species, that is whether they are single or double-brooded, etc., can thus be made out with tolerable certainty.

In the matter of arrangement of the species we follow in the main that given by Cambridge at the end of the "Spiders of Dorset," but the *Theridiidæ* are grouped under the genera given in Simon's "Arachnides de France." The name under which a spider is described, in Blackwall's "History" or in Cambridge's "Spiders of Dorset," is given where it differs from that employed by us.

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[1] Since the above was written we have (May 1894) obtained these two species; also *Singa hamata* (Cl.), *Chiracanthium carnifex* (Fabr.), and a few other interesting spiders at Callander.

All doubtful specimens have been submitted to Mr Cambridge, whose invaluable aid, at all times so willingly rendered, we would here gratefully acknowledge. The identification of most of the species now recorded for the first time as Scottish, has been verified by him.

Besides true spiders (*Araneidea*), the collection contains a considerable number of specimens belonging to other orders of Arachnida, namely, "Harvestmen" (*Phalangidea*) and "Pseudo-Scorpions" (*Chernetidea*): these we propose to enumerate in a subsequent paper.

SYSTEMATIC LIST OF SPECIES.

Order ARANEIDEA.

Family DYSDERIDÆ.

Dysdera cambridgii, Thor.

Dysdera erythrina, Blackwall's Spid. Great Brit. and Irel.

Very rare, a single example (an adult female) captured under a stone on the links immediately to the west of Pettycur, on the Fife coast, 29th June 1889, being the only one as yet detected.[1] As females of *D. cambridgii*, Thor., cannot with certainty be distinguished from those of *D. crocata*, C. Koch (= *D. rubicunda*, Bl.), we have been led to refer this specimen to the former species mainly upon general grounds, such as its greater abundance and more northerly distribution in England. The Rev. O. P. Cambridge has seen the specimen, and also thinks it most likely belongs to this species. This record is the first for Scotland. In England it has been found at various localities from Cornwall to Lincolnshire.

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[1] Since the above was sent to press, Mr Eagle Clarke has shown us another adult female, which was found on the south side of the Calton Hill, Edinburgh, in the beginning of May 1894.

Harpactes hombergii (Scop.).

Dysdera hombergii, Bl. Spid. Great Brit. and Irel.

Locally not uncommon, but not yet detected far inland. While the majority probably breed about the beginning of summer, others appear not to reach maturity till much later in the year.

Blackford Hill, Dec., adult ♂s and ♀s; Do., March, several ♀s; Aberdour, April, ♀ ad., others of both sexes immature; Arthur's Seat, April and May, ♂s and ♀s, some of each ad.; Morningside, June, ad. ♂; Braid Hills, August, two half-grown; Isle of May, August, ♂ and two ♀s.

Segestria senoculata (L.).

Everywhere common from the coast to the most inland localities, hiding in crevices of rocks and walls, among loose stones, and less frequently under the bark of old trees: hibernates in its snug silken cell: females, as is so frequently the case in this group, much oftener met with than males, and probably much longer lived. According to Blackwall, this spider lays its eggs in May or June, takes two years to reach maturity, and has been known to live four years. As we find very young individuals during winter, it would seem that the eggs do not hatch for several months after they are laid.

Colinton, M[illegible] [illegible], Jan., many very young, others (♀s) of all sizes up to a few full grown; Blackford Hill, Feb., one ♂ and a few ♀s ad., many imm. ♀s of various ages; Kinghorn, March, many, mostly imm., ♀s greatly preponderating; Aberdour, April, ads. of both sexes and many imm.; Morton, May, several ♂s, more ♀s ad. and imm.; Largo Links, Aug., ♀s ad. and imm.; Arthur's Seat, Aug., very young; Isle of May, Aug. and Sept., several ad. ♀s; Aberlady, Sept. and Oct., some ad. ♀s; Craigmillar and Torduff, Nov., ♂ and several ♀s ad., others imm.; Blackford Hill, three ♂s and numerous ♀s, both ad. and imm.; Bridge of Allan, Dec., a full-grown ♀, and several very young; etc.

Oonops pulcher, Templ.

This minute spider is widely but rather sparingly distributed. The majority probably pair in spring and summer;

but, like other species of the family, adults, especially females, occur at other seasons of the year.

Comiston, Jan., ♀; Braids, under whins, Feb., four ♀s; Hillend, Feb., ♀ imm.; Rosslyn, March, many ♀s; near Kirknewton, March, several ♂s and ♀s; Arthur's Seat, March and April, a few; Dalmeny Park, March and April, three ♀s; Aberdour and Inverkeithing, April, ad. ♂ and several ♀s; Longniddry Quarry, June, ad. ♂s and ♀s common, and a number imm.; Largo Links, Aug., two ♀s; Blackford Hill, Dec., one ♂ and several ♀s hybernating among stones.

Family **DRASSIDÆ.**

Micaria pulicaria (Sund.).

Drassus nitens + *D. micans*, Bl. Spid. Great Brit. and Irel.

Frequent, though never numerous, on banks and commons near the sea; less common inland; adults during spring and summer. Spiders as a rule avoid the company of ants, which prey upon them; but the present species (doubtless protected by its ant-like form) seems, in common with other well-known instances, to be an exception, for it may often be seen bustling about on a sunny bank in the midst of numbers of these busy creatures.

Salisbury Crags, in silken cells under stones, March and April, ♂ and three ♀s, some imm.; Arthur's Seat above Duddingston, March, two ♀s; Pettycur, March, ♂ and imm. ♀; Aberdour, April, three ♂s (two ad.) and four ♀s (two ad.); Braids, April, ♀; Do., Aug., ♀ imm.; Longniddry, June, two ad. ♀s; Largo Links, Aug., ♂ imm.; West Wemyss Station, Sept., two ♀s (one imm.); Gosford Links, Sept., ♀ imm.; Luffness Links, Oct., ♂ imm. and ♀; Pentlands above Bonaly, Oct., ♀; etc.

Prosthesima nigrita (Fabr.).

Drassus pusillus, Bl. Spid. Great Brit. and Irel.

Rare, five males and females (all more or less immature) captured on Luffness Links on 5th October 1893, being the only examples we have met with in the district; they were hidden among drifted sand about the stems of *Ammophila arenaria.* The only previous record for Scotland appears to be that of Mr Cambridge, who detected the species on Arthur's Seat in June 1861.

Drassus blackwallii, Thor.

Drassus sericeus, Bl. Spid. Great Brit. and Irel.

We have not been so fortunate as to meet with this spider, but Mr Cambridge captured a specimen among stones on Arthur's Seat in June 1861. Careful search about outhouses and old buildings after nightfall would probably reveal its presence in a number of localities.

Drassus troglodytes, C. L. Koch.

Drassus clavator, Bl. Spid. Great Brit. and Irel.

Widely distributed, and fairly common under stones, etc., lying on sunny banks and hillsides. It seems to be more of an upland species than the next; on the southern slopes of the Pentlands, for instance, we find it the more frequent of the two. Adult during the summer months.

Bavelaw Moor and south side of Carnethy (Pentlands), March, ♂ and two ♀s imm.; Pettycur Links, March, five ♂s and one ♀, all imm.; Inverkeithing, April, ♀ newly ad.; Braid Hills, Aug., four ♀s; Luffness Links and Gosford, Sept. and Oct., eight or nine ♀s, mostly imm.; summit of West Kipp (Pentlands), Oct., ♂ imm.; Pentlands above Boghall, Oct., five or six ♂s and ♀s imm.; Lothianburn and road south of Dalmahoy Hill, Nov., numbers of both sexes immature; etc.

Drassus lapidosus (Walck.).

Drassus lapidicolens, Bl. Spid. Great Brit. and Irel.

Generally distributed, and in most localities a plentiful species at all times of the year. Examples, however, with the reproductive organs fully developed, practically occur only towards the close of spring and during summer, and they are then probably more than one year old.

Braids and Hillend, under whins, Feb., imm. ♂s and ♀s in about equal numbers; Kirknewton, Blackford Hill, and Loganlee (Pentlands), March, numerous ♂s and ♀s imm.; Pettycur, end of March, ♀ ad. and others of both sexes imm.; Aberdour and Dalmahoy, April, ad. ♂s and ♀s, others imm.; Arthur's Seat and Aberlady, May and June, both sexes ad.; Peebles and Penicuik, July, several ♀s, one ad.; Isle of May, Aug., one ♂ young; Aberlady, Sept., ♂s and ♀s imm.; Bonaly, Ravelrig, and Rullion Green, Oct. and Nov., ♂s and ♀s, some of latter large, but all still immature; Braids and Swanston, Nov., ♂ and ♀s imm.; Bridge of Allan, Dec., two ♀s scarcely half grown; etc.

Clubiona grisea, L. Koch.

Clubiona holosericea, Bl. Spid. Great Brit. and Irel.

Apparently local, but seemingly plentiful where it does occur. Adults in autumn. In the south of England and in France, according to Mr Cambridge and M. Simon, this species pairs about May.

Luffness Links, about the marshes and ditches, Sept. and Oct. 1893, ad. ♂s and ♀s equally common, especially among iris, where dozens might have been captured in a few minutes. Identification verified by Mr Cambridge. The only other record for Scotland was furnished by Dr Hardy, from Berwickshire.

Clubiona terrestris, Westr.

Clubiona amarantha, Bl. Spid. Great Brit. and Irel.

Generally distributed, and (especially females) very common among rough herbage, underwood, etc. Pairs towards close of spring and in early part of summer, when, and until the foliage drops in autumn, great numbers may be found on beech hedges, bramble thickets, etc., concealed in folded leaves.

Braids, under whins, Feb., ♀; Rosslyn, March, ♂; Blackford Hill and Kirknewton, March, several young ♀s; Pettycur, end of March, two ♀s ad., and numerous young ♀s; Aberdour, April, two ♀s ad., others immature of various ages; Hopetoun and Dalkeith, April, ♀s imm.; Balerno, April and May, ♀s ad. and imm., ad. ♂s early in June; Seafield, etc., end of June, ad. ♀s, and many very young; Dreghorn, Rosslyn, and Penicuik, July, common on beech hedges, etc., mostly immature or young, several ad. ♀s beside their eggs or newly-hatched progeny; Kirknewton, Leven, Wemyss, etc., August, a few ad. ♀s, many immature and young; Pentlands, Sept., ♂ and two ♀s imm.; Luffness Links, Sept., many imm., some quite young; Dalmahoy, Nov., two ♀s imm.; Bridge of Allan, Dec., four ♀s imm.; etc.

Clubiona reclusa, Cambr.

Widely distributed, but not so common as the last, to which it is closely related both in habits and appearance. We have found no adult males, but it seems clear that pairing takes place here in summer, as M. Simon has observed in France.

By Braidburn, under bank, Feb., two ♀s ad. and young; Hillend, Feb., ♀ imm.; Kirknewton, Balerno, and Loganlee, March, several ♀s, some young, others well grown but still immature; Aberdour, April, half-a-dozen

♀s, one ad., others young or immature; Rosslyn and Penicuik, July, ad. ♀s; Kirknewton, 9th Aug., numerous ad. ♀s beside their eggs in folded leaves of honeysuckle; West Wemyss Station, under loose bark on old paling, Aug., a number of ad. ♀s, also many imm. and young; Balerno, Sept., ♀ $\frac{3}{4}$ths grown; Boghall, Oct., three ♀s imm.; etc.

Clubiona pallidula, Clk.

Clubiona epimelas, Bl. Spid. Great Brit. and Irel.

Rare. In September 1888, females of this species were fairly numerous in folded beech leaves, on a hedge near Gullane in East Lothian, but we have not yet detected it elsewhere in the district. Specimens submitted to Mr Cambridge for verification. Has been recorded from a few localities in the west and north of Scotland.

Clubiona holosericea, De Geer.

Rare. Two mature females (identification verified by Mr Cambridge), and several immature examples, probably also belonging to this species, were obtained under logs on Luffness Links, on 14th September 1888; and on 23rd March 1890, an adult female was taken near Edinburgh. Recorded from near Aberdeen and Paisley. It is not unlikely that, in the immature state, examples of both this and the previous species have been passed over by us as belonging to one of the commoner kinds.

Clubiona brevipes, Bl.

Apparently far from common. In April 1893 we captured three females, not quite mature, near Aberdour in Fife. Mr Cambridge records having found it on the Pentlands above Currie, in June 1861, and Dr Hardy has taken it in Berwickshire.

Clubiona compta, C. L. Koch.

Generally distributed and fairly common. Adults of both sexes found in summer. In France the male is already adult in April.

Blackford Hill, by Braidburn, Rosslyn, and Currie, March, a number of half-grown females; Aberdour, April, ♂ and four ♀s—two of the latter ad.;

Aberlady, May, ad. ♂ and ♀; Dreghorn, June, ad. ♂; Rosslyn, July, numbers of various ages, a few ♂s ad.; near Leven, Aug., several ♂s imm.; Greenbank, under loose bark on old paling, Dec., two ♂s, one mature.

Clubiona trivialis, L. Koch.

Local,—being partial to heathery moors; but fairly common where it occurs. Both sexes are to be met with in the adult state during summer, when the female constructs a small silken cell among twigs of heather, in which she deposits her eggs and takes up her abode.

Ravensnook Moor near Penicuik, 28th July 1893, two ad. ♂s and an imm. ♀; Moor near West Wemyss Station, Fife, Aug., ad. ♂s and ♀s common, a number of the latter in their silken cells; Bavelaw Moss, and Pentlands near Allermuir burn, Sept., ♀s, several imm.; Pentlands above Boghall, Oct., two ad. ♀s. Taken by Mr Cambridge on the Pentlands in June 1861.

Clubiona diversa, Cb.

Clubiona pallens, Cambr. Spid. Dorset.

Widely distributed, occurring in many localities about the roots of grass, moss, etc., but always in very limited numbers. Both sexes occur in the adult state in autumn as well as in spring. Mr Cambridge (who has seen some of our specimens) regards this as one of the rarer British species. It has already been recorded, however, from a few Scottish localities.

Near Kirknewton, March, two ♀s, one young; Loganlee (Pentlands), end of March, one ♂; Leadburn, March, two ad. ♂s and several ♀s; West Wemyss Moor, Aug., ad. ♂; Luffness, Sept., ad. ♂; Gosford, Sept., ad. ♂; Luffness Links, Oct., ♂ and two ♀s; Pentlands, near Boghall, Oct., two ♂s and three ♀s, others imm.; roadside, south of Dalmahoy Hill, Nov., one ♀ imm.; Ochils above Bridge of Allan, at roots of heather, Dec., ad. ♂ and two ♀s.

Clubiona subtilis, L. Koch.

Clubiona pallens, Bl. Spid. Great Brit. and Irel.

Apparently a rare species here, a single example—an adult female—taken near Temple, on 27th July 1893, being the only one as yet detected. This is its first record for Scotland.

Zora spinimana (Sund.).

Hecäerge spinimana, Bl. Spid. Great Brit. and Irel.
Hecäerge maculata, Cambr. Spid. Dorset.

Apparently very local here as elsewhere in Scotland. It has been taken in Berwickshire, and also near Aberdeen.

West Wemyss, Fife, at roots of heath in a young fir plantation, 26th Aug. 1893, eight specimens (three of them ad. ♀s), and on 4th Sept. three more; roadside, near Largo, 7th Sept., one ad. ♀; Keilsden, near Largo, 7th Sept., a dozen, all more or less immature; wood near Kirknewton, among heather, 18th May 1894, ♂ and two ♀s ad., and a number half-grown.

Micariosoma festiva (C. L. K.).

Drassus propinquus, Bl. Spid. Great Brit. and Irel.
Phrurolithus festivus, Cambr. Spid. Dorset.

Very local. Mr Cambridge found it not uncommon on Arthur's Seat in June 1861, but up to the present time we have failed to rediscover it in that locality. We have, however, met with it under stones on a rough bank overlooking the harbour at Aberdour, where, in April 1893, numerous specimens were captured, a few of them being adult males.

Agroëca proxima, Cambr.

Widely distributed and fairly common. The majority probably attain maturity in spring and early summer: adult females and very young examples frequent in autumn. None of our specimens, several of which have been shown to Mr Cambridge, are referable to the closely-allied form *A. brunnea* (Bl.).

Dalmeny Park, 28th Jan., one ♀; West Wemyss Station, at roots of heath in young fir plantation, 26th Aug., ♂ and two ♀s ad.; and at same place on 4th September, three ad. ♀s and one imm.; roadside near Largo, 7th Sept., ad. ♀; Bavelaw Moor, and Pentlands above Glencorse, Sept., two ♀s ad. and several young; Luffness Links, Gosford, Gullane, and Tyninghame, Sept., several ad. ♀s, others not quite mature, and numerous juveniles; Buckstone, North Morton, and Bonaly, Oct. and Nov., several ♀s not quite mature.

Agroëca gracilipes (Blackw.).

Agelena gracilipes, Bl. Spid. Great Brit. and Irel.
Liocranum gracilipes, Cambr. Spid. Dorset.

Apparently very far from common, a single specimen—an immature female, identified by Mr Cambridge—taken at Pettycur in April 1893 being the only one as yet detected. Mr Cambridge informs us that the only other Scottish example he has seen was taken near Paisley.

Family **DICTYNIDÆ.**

Dictyna arundinacea (Linn.).

Ergatis benigna, Bl. Spid. Great Brit. and Irel.

Locally common, but practically confined to uncultivated spots covered with tall heather, on the branches of which it constructs its slight snare and domicile. Both sexes are adult in May, and are then to be found living together in the same webs.

Bavelaw Moss, May, ad. ♂s and ♀s; Do., Sept., numbers imm.; Ravensnook Moor near Penicuik, July, one ad. ♀, and numerous imm. examples of both sexes; Moss near Thornton, Fife, Aug. and Sept., abundant but imm., mostly on heather—some on spruces and also on rushes; Drumshoreland Moor, Sept., a few imm.; near Bridge of Allan, Dec., several very young examples on heather; etc.

Dictyna arenicola, Cb. (sp. n.).

In Sept. 1893, numerous immature examples of a *Dictyna* not unlike the last species, but much paler, were obtained about the roots of "marram" grass on the sandhills at the far end of Luffness Links, and skirting the eastern shore of Aberlady Bay. A few were shown to Mr Cambridge, who replied:—"These are pale specimens, but strongly marked and very like *D. borealis*, Cambr. (from Greenland), but being quite young I should hesitate to name them so. Adults from the same locality as these were found in would be very desirable." Accordingly in the beginning of June 1894 we revisited the spot, and were fortunate enough to find a few adults running in the sunshine on the warm sand. All were males, however, and as the type of *borealis* is a female, the discovery of adult females of the Luffness spider was most important. A second search having produced only one or two more males, a third visit to the sandhills was made on 16th June, this time with complete success. At first only males (fully a dozen) were obtained, all running as before on the warm sand. The "marram" grass and thistle-heads were searched and swept in vain for the females, which in the end were found by the merest chance concealed in bits of dry seaweed (*Fucus*) and withered leaves lying on the sand. In these they had constructed their domiciles and placed their egg-cocoons, of which they make several, each containing about fifteen to twenty eggs (three opened contained sixteen, seventeen, and nineteen respectively; and one opened in the beginning of July contained newly hatched young). The discovery of this habit at once revealed their presence in considerable numbers. After examining about a dozen of each sex, Mr Cambridge has come to the conclusion that they belong to an undescribed species. "I would propose for it," he writes, "the name *Dictyna arenicola*, nearly allied to, but, I think, quite distinct from *D. borealis*, Cambr., from North Greenland (*Ann. and Mag. Nat. Hist.*, 1877, p. 273)." This new form is described (and figured) by Mr Cambridge in an Appendix to the present paper (p. 589, Pl. XII.).

Amaurobius fenestralis, Str.

Ciniflo atrox, Bl. Spid. Great Brit. and Irel.

Universally distributed and very common, from the Isle of May to the most inland localities, making its dens in holes in walls, crevices in rocks, under loose bark on old trees, in dense whin bushes, etc.; occasionally also in houses, where, however, it gives place to the next species. We have noted adults of both sexes in every season of the year, and very young examples in mid-winter as well as during summer. In August last, specimens of all ages (including adult males) were shaken out of the debris under whin bushes on the Braid Hills.

Amaurobius similis (Bl.).

Ciniflo similis, Bl. Spid. Great Brit. and Irel.

Widely distributed and common, but not nearly so abundant as the preceding species; chiefly an inhabitant of houses, and holes in walls in their immediate vicinity. Adults noted from autumn to spring.

Morningside Park, Edinburgh, in house, Jan., Oct., and Dec., ad. ♂s and ♀s common; Dalmeny, March, ♂ and several ♀s; rocks near Kinghorn, and on Arthur's Seat, March, several ♀s, some imm.; Hopetoun, in greenhouse, April, ♂; Aberlady, on garden walls, etc., Sept. and Oct., numerous ♂s and ♀s; rocks at Blackford Hill Quarry, Dec., ♂ and three ♀s; etc.

Amaurobius ferox (Walck.).

Ciniflo ferox, Bl. Spid. Great Brit. and Irel.

Apparently rare, the three examples mentioned below being the only ones we have yet met with. Although common in England, especially in the southern counties, it does not appear to have been previously noticed in Scotland.

On kitchen hearth, 18 Morningside Park, Edinburgh, 29th March 1893, an adult ♂ (another escaped); Aberdour, among stones on steep bank a little to the east of the village, and overlooking the harbour, 6th April 1893, an adult ♀.

Family **AGELENIDÆ.**

Argyroneta aquatica (Clk.).

The water-spider must be regarded as a very local species, although it doubtless occurs in other localities than the two from which it has already been recorded: suitable habitats, however, are now scarce in the district.

The known localities are:—Luffness Marshes near Aberlady, where the species was detected by Mr A. Gray in 1884 (*Proc. Roy. Phys. Soc.*, viii., 504); and Bavelaw Moss near Balerno, where Mr A. B. Herbert discovered it in August 1885 (*Proc. Edin. Nat. Field Club*, i., 297). Our collection contains adults of both sexes and immature examples taken in these habitats in March, April, May, and June; also specimens taken in September. The chief plant in the pools it inhabits at Luffness is *Chara hispida*, those at Bavelaw are filled with *Sphagnum cuspidatum*.

Cryphœca sylvicola (C. L. Koch).

Tegenaria sylvicola, Bl. Spid. Great Brit. and Irel.

Widely distributed and common, especially in sub-alpine districts, where any number of specimens may be obtained under loose stones on the tops of old walls. Adults of both sexes from autumn to spring.

Mortonhall, under bark, Feb., two ♀s; Hillend Wood, Pentlands, under stones, Feb., numerous ♂s and ♀s, both ad. and imm.; Bonaly Glen, under heather, Rosslyn, Woodhouselee, Kirknewton, Braid, Bavelaw Moss, Craiglockhart Wood, Currie Moor, mostly on walls, March, many ad. ♂s and ♀s; Dalmeny, April, two ♀s; Ravensnook Moor, July, several imm. ♂s and ♀s; Keilsden, and Lundin Tower, near Leven, Sept., ♂s and ♀s; Bonaly, North Morton, and Rullion Green, Oct., ad. ♂s and ♀s; Swanston, Nov., numerous ♀s, mostly imm.; Comiston, Torduff, and Bridge of Allan, Dec., a good many of both sexes, some immature; etc.

Tegenaria derhamii (Scop.).

Tegenaria civilis, Bl. Spid. Great Brit. and Irel.

This, the common house-spider, is, it need hardly be said, a generally distributed and abundant species, inhabiting dwelling-houses and other buildings. On two occasions only have we met with it out of doors, namely, on Salisbury Crags in April, and on the Isle of May in August—in each instance a single specimen under stones. Adults probably occur throughout the year; we have noted them in spring, autumn, and winter.

Textrix denticulata (Oliv.).

Textrix lycosina, Bl. Spid. Great Brit. and Irel.

Generally distributed and very common on the hills as well as on the plains. Every locality examined—the Isle of May included—has yielded it. Hibernates under stones, etc., in a silken cell. Adults and immature examples observed at all seasons; very young examples noted in December and January, also in June and August. M. Simon mentions only the summer breeding-time.

Hahnia elegans (Bl.).

Agelena elegans, Bl. Spid. Great Brit. and Irel.

Rare, the only examples we have met with being a few taken near Kilconquhar in Fife last September, as noted below. The present seems to be the first record of its capture in a Scottish locality, Coldmartin Moss not being in Berwickshire, as stated in Mr Cambridge's 1877 paper (*Entomologist*, 1877, p. 174), but near Wooler in Northumberland.

Among damp moss in a swampy spot between Kilconquhar Railway Station and the village, 5th Sept. 1893, three ♂ s and five ♀ s.

Hahnia nava (Bl.).

Agelena nava, Bl. Spid. Great Brit. and Irel.

Among small loose stones, etc., on hilly places, not uncommon; and, curiously enough, not hitherto recorded from Scotland. Adults of both sexes from October to May.

Pentlands above Boghall, among loose stones, Oct., about a dozen, some of both sexes mature; North Morton, Oct., ad. ♂ ; Braid Hills, among débris under whin bushes and among small stones, Nov., ♂ and five ♀ s; again, Feb. and May, ad. ♀ s; Salisbury Crags, March, three ♂ s and one ♀ ; Arthur's Seat, March, numerous, mostly ♂ s; again, April, mostly ♀ s.

Hahnia montana (Bl.).

Agelena montana, Bl. Spid. Great Brit. and Irel.

Among loose stones, etc., in hilly districts; apparently rather less common than the preceding; was taken on the Pentlands above Currie by Mr Cambridge in June 1861; has also been recorded from Berwickshire, and one or two other Scottish localities.

Blackford Hill, March, three ♀ s, one of them mature; Pentlands by path leading from Glencorse Reservoir to Currie, Sept., a dozen ♀ s, some ad. and one ♂ imm.; south side of Turnhouse Hill, Pentlands, Oct., several ♀ s, mostly imm.; Braid Hills, Oct., one ♀ , others imm.

Family **THERIDIIDÆ.**

Ero furcata (Vill.).

Theridion variegatum, Bl. Spid. Great Brit. and Irel.
Ero thoracica, Cambr. Spid. Dorset.

Generally distributed, but never numerous, seldom more than two or three being found together. Apparently to be found adult from early spring till autumn.

By Braidburn above Greenbank, Feb. and March, four ad. ♀s; Braid Hills, Feb., ad. ♂ and young ♀; Hillend, Feb., ♀; Bonaly Glen, March, ♀; Woodhouselee, March, ♀ and two young; Pettycur, March, ♀; Aberdour, April, ♀; Braids, Aug., ♂; Kilconquhar, Sept., imm. ♀; Bonaly, Oct., imm. ♀; Luffness, Oct., imm. ♀; Boghall (Pentlands), Oct., young ♀.

Nesticus cellulanus (Clk.).

Linyphia crypticolens, Bl. Spid. Great Brit. and Irel.

Widely distributed, but nowhere very common.

Under overhanging bank by Braidburn, Feb., two ♂s and two ♀s, all young, and one ♀ ad.; by ditch at Comiston, March, five ♀s; Balerno, March, ♀; Dreghorn, March, young ♀; July, imm. ♀; Aberdour, April, imm. ♀; Keilsden near Largo, Sept., ♀; Bonaly, Oct., imm. ♀.

Theridion lineatum (Clk.).

Phyllonethis lineata, Cambr. Spid. Dorset.

Except in the bleak upland districts, this is a generally distributed and very common species. Young examples are to be met with in the early part of the year; they attain maturity in June and July, and immediately after pairing the males disappear. The females, however, are to be found beside their eggs (concealed in folded leaves on bushes, hedges, nettles, etc.) far into the autumn, some lingering even into winter, when the first spell of frost kills them off. The pretty varieties with the red markings on the back are not uncommon.

Corstorphine Hill and Dalkeith, April, several young; Greenbank, May, numbers of young; Seafield, etc., June, numerous ad. ♂s and ♀s; Colinton, Rosslyn, Penicuik, etc., July, ad. ♂s and ♀s (especially the latter) very common; by Comiston path, Arthur's Seat, Kirknewton, Braids, etc., Aug., ♀s beside their eggs, very common; Aberlady, Gullane, Drem, Leven, Kennoway, Largo, etc., Sept., ♀s with their eggs and young, abundant; Greenbank, Oct., a few ♀s; in Dec. shrivelled up remains of ♀s in their nests, and some very young examples shaken from among roots of grass, etc.

Theridion tepidariorum, C. L. K.

Abundant in most large greenhouses and conservatories. Examples of all ages are probably to be found at all seasons.

Orchid houses, Bridge of Allan, Jan., ad. ♂ and several ♀s beside their eggs, also many in various stages of immaturity; Edinburgh Botanic Garden, Gardens at Hopetoun, Dalkeith, etc., April, ad. ♀s and young examples numerous; Gosford Gardens, Sept., ad. ♀ and several imm.

Theridion pictum, Hahn.

In gardens and pleasure-grounds; rare. Has been taken at Dunkeld by Professor Trail.

Edinburgh Botanic Garden, 25th March 1893, three imm. ♀s on *Araucaria;* Gosford Grounds, 20th Sept. 1893, on a tall heath, ad. ♀ and two young ♀s.

Theridion sisyphium (Clk.).

Theridion nervosum, Bl. Spid. Great Brit. and Irel.

A widely distributed and abundant species. In the suburbs of the city it is common in villa gardens, constructing its nest among the leaves of various shrubs and conifers—especially *Pinus austriaca.* In the country it is chiefly found on whins, juniper, and tall heather. During the pairing season, May and June, the males and females are to be found together in the same nest; the males then disappear, and the females remain beside their eggs and young till autumn, when they, too, gradually die off. Young examples may be found in the nests throughout the winter.

Craighouse, Jan., ad. ♀ and several young ♀s; Edinburgh Botanic Garden, Colinton, Currie, Dalkeith, March, common, imm.; Aberdour, April, ad. ♀ and many imm.; Hopetoun, April, ad. ♂, and several imm. ♀s; Corstorphine, Braids, etc., May, June, ad. ♂s and ♀s com.; Dreghorn, Penicuik, Rosslyn, June, July, ♀s beside their eggs, common; Merchiston, Kirknewton, Aug., ♀s common; Balerno, Leven, ad. ♀s and young; Gosford, Luffness, ad. ♀s and others imm.; Mortonhall, Oct., imm. ♀s; Merchiston, Dec., young ♀s in nests, etc.

Theridion denticulatum, Walck.

Not uncommon on ornamental shrubs and conifers in large gardens and pleasure-grounds in sheltered spots, but practically confined to such localities. Adult about the beginning of summer.

Dalmeny Park, April, ♂s and ♀s, some nearly mature; Gosford Grounds, on conifers, etc., Sept., numerous imm. ♂s and ♀s; Luffness, Oct., imm. ♀ on a gate.

Theridion varians, Hahn.

In same situations as the last; not common.

Hopetoun Grounds, April, on yew, three ♂s; Silverburn near Leven, on *Wellingtonia*, Aug., young ♀; Gosford, Sept., ♀ and three young.

Theridion pallens, Bl.

On shrubs and other low bushes; not common.

Aberdour, on whins, April, two ♀s; Hopetoun, on yew, April, ♂ and two ♀s; Gosford, Sept., ♂ and three ♀s imm.

Pholcomma gibbum (Westr.).

Widely distributed, and fairly common among the débris under whin bushes, heather, etc. Adult males obtained in autumn as well as in spring.

Braid and Blackford Hills, Hillend (Pentlands), Dreghorn, Bonaly Glen, Balerno, Feb. and March, many ad. ♂s and ♀s; Aberdour and Bavelaw Moss, April and May, a few ♂s, more ♀s; Pentlands (near Glencorse Reservoir), Sept., numerous ad. ♂s and ♀s; Keilsden and moss near Thornton (Fife), Aug. and Sept., a few ♀s; Mortonhall, and Boghall (Pentlands), Oct., a few ♀s.

Crustulina guttata (Wid.).

Theridion guttatum, Bl. Spid. Gr. Brit. and Irel.
Steatoda guttata, Cambr. Spid. Dorset.

This interesting and distinctly marked little species seems to be very local—the two localities after-mentioned being the only places in which we have, as yet, detected it. This is the first record of it for Scotland.

Braid Hills, near the west end, among the débris under whin bushes, 2nd Feb. 1893, two ♂s and a ♀ ad., and two young; same locality, 21st Feb., six ad. ♂s and ♀s; Blackford Hill under whins, 16th March, two ♂s and one ♀ ad., and two young ♀s.

Pedanostethus neglectus (Cb.).

Neriene neglecta, Cambr. Spid. Dorset.

Apparently a rare spider, only two examples (both adult males) having as yet been detected. Mr Cambridge, who identified our first specimen, had previously received (and recorded) the species from Paisley.

Temple (Midlothian), one ♂, 27th July 1893; near Leven (Fife), one ♂, Sept. 1893.

Pedanostethus lividus (Bl.).

Neriene livida, Bl. Spid. Gr. Brit. and Irel., and Cambr. Spid. Dorset.

Generally distributed and common, especially in the upland districts, where it ascends quite to the hill-tops. Adult males frequent from autumn to spring. Would seem to breed twice a year, as we have found females beside their egg-cocoons in April and October. Sixty-six eggs, many of which hatched during first week of May, were taken from one cocoon.

Pentlands (above Hillend) and Dalmeny Park, Feb., ad. ♂s and ♀s; Boghall, Kitchen Moss, and Carnethy (Pentlands), March and April, ad. ♂s and ♀s—two beside egg-cocoons; Aberdour, April, several ♂s and ♀s, some imm.; Ravensnook Moor, July, two ad. ♀s; Aberlady, Pentlands, Bavelaw Moss, Sept., a few ad. ♂s and ♀s; Pentlands above Boghall, Bonaly Glen, Bavelaw Castle, and summit of Scaldlaw, Oct., many ad. ♂s and ♀s—some beside egg-cocoons; Pentlands above Hillend, etc., Nov., ad. ♂s and ♀s.

Tapinopa longidens (Wid.).

Linyphia longidens, Bl. Spid. Gr. Brit. and Irel.

Widely distributed, but not plentiful. Probably breeds in spring as well as in autumn, though we have observed adult males and egg-cocoons only during the latter season. The number of eggs in one of the cocoons was forty-nine.

Braid Hills, Feb., four ♀s; Aberdour, April, two ♀s; Roslyn, July, imm. ♀; Arthur's Seat, Aug., several ♂s and one imm. ♀; Wemyss and Largo (Fife), Aug., two ♂s and two ♀s ad.; Luffness and Gullane Links, Sept., two ♂s and about twenty ♀s, all ad.; Scaldlaw (Pentlands), Oct., one ♀; Caerketton Hill (south side of), 20th Oct., one ad. ♂, and numerous ♀s beside their egg-cocoons in hollows under stones; Boghall, Nov., ad. ♀.

Bolyphantes luteolus (Bl.).

Linyphia alticeps, Bl. Spid. Gr. Brit. and Irel.
Linyphia luteola, Cambr. Spid. Dorset.

This is one of the most widely distributed and abundant spiders in the district. In the immediate vicinity of the city it is quite as common as in the outlying localities. Behind grass growing at the foot of a wall is a favourite habitat. A hardy species, there being few days throughout the winter when it cannot be obtained with ease. Adults of both sexes from autumn to spring—most abundant, however, about end of autumn and beginning of winter.

Roadsides south of Edinburgh, Pentlands, etc., Jan. and Feb., several ad. ♂s and many ♀s, one young; March, a number of ad. ♀s; April, one ad. ♂ and a few ♀s; Rosslyn, Penicuik, Temple, etc., June and July, many imm. ♂s and ♀s; Braids, Kirknewton, Drumshoreland, Leven, Elie, Isle of May, etc., Aug. and Sept., abundant, numbers of both sexes now mature; Aberlady, summit of Scaldlaw (Pentlands), etc., Oct., ad. ♂s and ♀s common; roadsides about Morningside, Craiglockhart, Juniper Green, Craigmillar, Hillend, etc., Nov. and Dec., ad. ♂s and ♀s very common.

Bolyphantes alticeps (Sund.).

Linyphia alticeps, Cambr. Spid. Dorset.

Rather local, but fairly plentiful where it occurs; more partial to wooded districts than the last.

Spinkie Den near Leven, Fife, among grass, especially at roots of trees, 28th Aug. 1893, ad. ♂s common, and a few ♀s; Kielsden near Largo, Aug. and Sept., ad. ♂s and ♀s com.; Drumshoreland, Sept., several ♂s and ♀s; Luffness Woods, Mortonhall, and The Bush near Rosslyn, Oct., ad. ♂s and ♀s fairly common.

Drapetisca socialis (Bl.).

Linyphia socialis, Bl. Spid. Gr. Brit. and Irel.

Locally not uncommon—occasionally even abundant—on tree-trunks and lichen-covered rocks. Adult in autumn.

Rosslyn, July, imm. ♀s; near Thornton, Spinkie Den and Lundin Tower (Leven), Keilsden (Largo), and Raith, Aug. and Sept., ad. ♂s and ♀s abundant, especially on large beeches; Luffness Woods, Sept., common; Dreghorn Avenue, Oct., a few ♂s and ♀s.

Linyphia insignis, Bl.

An abundant species in all the well-wooded parts of the district. From June to September great numbers may be obtained by beating beech hedges, bushes, and the lower branches of trees. For a time only young and immature examples will be obtained; but by about the middle of August, or a little later, a few will be found to have undergone their final moult, and in a few days adults become the rule. As autumn passes into winter they gradually disappear.

Dreghorn, Rosslyn, Penicuik, etc., June and July, very common, but all young; Leven, Largo, Raith, etc., Aug., very common—first ad. ♂s on 21st, numerous by end of month; Balerno, Drumshoreland, Gosford, etc., Sept., adults com.; The Bush, Dreghorn, etc., Oct., adults, mostly ♀s; Colinton, Dec., one ♀; Bridge of Allan, Dec., one ♀; Braid Hermitage, 7th Feb., one ♀.

Linyphia lineata (L.).

Neriene trilineata, Bl. Spid. Great Brit. and Irel.
Linyphia bucculenta, Cambr. Spid. Dorset.

Widely distributed and common: adults from autumn to spring.

Comiston and Buckstone, under stones, Jan., five ♂s and three ♀s ad.; Braid Hills and Hillend, under whins, Feb., a dozen ad. ♂s and ♀s and several young; Arthur's Seat, roadside south of Edinburgh, and at Pettycur, March, a number of ad. ♂s and ♀s; Aberdour, April, an ad. ♂; Rosslyn and Penicuik, July, a few imm.; Arthur's Seat, Aug., imm. ♂; Luffness Links, Oct., ad. ♂ and two ♀s of a dark variety; North Morton, Oct., two ad. ♂s and imm. ♂ and ♀.

Linyphia clathrata, Sund.

Neriene marginata, Bl. Spid. Great Brit. and Irel.

Generally distributed and abundant: adult males from autumn to spring.

By Braidburn, Colinton, North Morton, Hillend, under overhanging banks, hedges, etc., Feb., many ad. ♂s and ♀s and a number of young; Comiston, Rosslyn, Balerno, Kirknewton, Dalkeith, Otterston, March, April, May, ad. ♂s and ♀s and a good many young; Longniddry, June, ad. ♀; Colinton, Boghall, Rosslyn, July, several ad. ♀s and many imm. ♂s and ♀s; Wemyss, Leven, Kilconquhar, Aberlady, Aug. and Sept., ad. ♂s and ♀s and a number imm.; The Bush and Dreghorn, Oct. and Nov., a few ad. ♂s and several young; Braid, Greenbank, Bridge of Allan, Dec., a dozen ad. ♂s and ♀s.

Linyphia montana (Cl.).

Linyphia marginata, Bl. Spid. Great Brit. and Irel.

This is a local and by no means common spider in the district; partial to young conifers and ornamental bushes in pleasure-grounds; pairs about the beginning of summer. In 1877 Mr H. C. Young took it at Dunoon and Rannoch, and recorded it as new to Scotland (*Proc. Glas. Nat. Hist. Soc.*, iii., 351). Although not in Mr Cambridge's list of Scottish spiders (*Entomologist*, 1877), it had, however, been recorded from Berwickshire by Dr Hardy as long ago as 1858 (*Proc. Berw. Nat. Club*, iv., 94).

Rosslyn, March, one mature ♀ and several imm. ♂s and ♀s; Raith April, imm. ♀; Dalmeny Park, May, ad. ♂ and ♀ and imm. ♀; Rosslyn, July, ad. ♀; Gosford Grounds, Sept., ♀ and imm. ♂ and young ♀.

Linyphia triangularis (Cl.).

Linyphia montana, Bl. Spid. Great Brit. and Irel.

Generally distributed and abundant, spreading its conspicuous webs on hedges, bushes, woodrush, etc. From May to July young and immature examples only are to be met with; during August the majority attain the adult state.

Gosford, etc., May, numerous young; Seafield (on broom), Dreghorn, etc., June, many imm.; Dryden and Rosslyn Glens (on *Luzula sylvatica*), Penicuik, Edgelaw, etc., July, very common, but nearly all imm. yet—first ad. ♂ observed 27th, a few more (with ad. ♀s) on 29th; Leven, Largo, Drem (on hedges, etc.), Gifford (on broom and whin), Balerno, Drumshoreland, Aug. and Sept., ad. ♂s and ♀s very common.

Linyphia peltata, Wid.

Linyphia rubea, Bl. Spid. Great Brit. and Irel.

Fairly abundant on yew bushes, young conifers, etc., in pleasure-grounds: adult about the end of spring or beginning of summer.

Rosslyn, March, several young ♂s and ♀s; Donibristle, Raith, Dalmeny Park, Hopetoun, April, numerous imm.—a few ad. ♂s on 4th, 8th, 17th, and 24th; May, ad. ♂s and ♀s; Dreghorn, June, ad. ♂; Penicuik, July, imm. ♀; Leven, Largo, Gosford, Aug. and Sept., young examples—mostly ♂s—com.; Luffness, near Rosslyn, etc., a number of young.

Linyphia pusilla, Sund.

Linyphia fuliginea, Bl. Spid. Great Brit. and Irel.

Widely distributed, but not very common; adult about same time as the last.

Bavelaw and Kirknewton, May, ad. ♂ and a few ♀s; Leven, Aug., young ♂; marshy ground near Kilconquhar, Sept., imm. ♂s and ♀s common on webs among the grass; Balerno, Sept., young ♂; Bonaly Glen, Oct., imm. ♀.

Linyphia hortensis, Sund.

Linyphia pratensis, Bl. Spid. Great Brit. and Irel.

Apparently very rare, a female captured by the roadside near Mortonhall south gate, on 23rd March 1890, being the only example as yet obtained. It has been recorded from a few widely separated Scottish localities.

Labulla thoracica (Wid.).

Linyphia cauta, Bl. Spid. Great Brit. and Irel.
Linyphia thoracica, Cambr. Spid. Dorset.

Occasionally met with, but by no means common.

Rosslyn Glen, under overhanging bank, March, one ♀ and three young; Rosslynlee, 26th July, ♂ and ♀ not quite mature; near Penicuik, July, two imm. ♀s; Temple, 27th July, one ad. ♂ and two imm. ♀s; Bridge of Allan, Dec., two imm. ♂s and two ♀s.

Leptyphantes minutus (Bl.).

Linyphia minuta, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Not of general occurrence, and seldom common: adult in autumn. The identification of all the species, here recorded, of this difficult genus has been confirmed by Mr Cambridge.

Dalmeny, April, ♀; Rosslyn, July, imm. ♂ and ♀; Spinkie Den near Leven, about tree trunks (in hollows and under loose bark), Aug., many ad. ♂s and ♀s and a few imm.; Arthur's Seat, Aug., ♀ and imm. ♀; Keilsden near Largo, Sept., two ♂s and ♀ ad.; Gosford and Luffness Woods, Sept. and Oct., several ad. ♂s and ♀s; Duddingston and Mortonhall, Oct., a few ad. ♂s and ♀s; near Colinton, Nov., three ♀s.

Leptyphantes nebulosus (Sund.).

Linyphia vivax, Bl. Spid. Great Brit. and Irel.
Linyphia nebulosa, Cambr. Spid. Dorset.

Rare, and probably only to be found about houses or in their immediate neighbourhood. The only previous record for Scotland is that of Mr H. C. Young, who obtained specimens in a building near Glasgow.

Above door of house, Morningside Park, Edinburgh, Dec. 1892, ad. ♂ and five ♀s; under wooden trough outside same house, 8th Feb. 1893, seven ad. ♀s.

Leptyphantes alacris (Bl.).

Linyphia alacris, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Fairly well distributed, but as a rule rather scarce; adults practically throughout the year.

Bridge of Allan, 3rd Jan., two ♂s and ♀; Rosslyn Glen, among grass and other herbage on steep rocky bank, 8th March, seven ad. ♂s, numerous ad.

♀s and young; near Balerno, March, ♂ and ♀; Aberdour and Otterston, April, several ♀s; Dryden Glen, on *Luzula*, July, com.; Temple, July, ad. ♂; Luffness Woods, Sept., ♂ and ♀; The Bush, Oct., four ♂s and two ♀s; Blackford, Dec., two ♂s and ♀.

Leptyphantes leprosus (Ohl.).

Linyphia leprosa, Cambr. Spid. Dorset.

Widely distributed, and fairly common at most times of the year.

Braid, Feb., ad. ♀; Blackford Hill, Botanic Garden, Currie, and Dalmeny Park, March, ad. ♂ and several ♀s; Arthur's Seat and Salisbury Crags, among stones, March and April, ad. ♂ and numerous ♀s; Temple, July, three ad. ♀s; Leven, etc. (Fife), Aug. and Sept., common; Aberlady, Sept., several ♀s; Craigmillar, at foot of wall, Nov., ad. ♂ and two ♀s; Greenbank Farm and Torduff near Colinton, Dec., several ♀s.

Leptyphantes obscurus (Bl.).

Linyphia obscura, Bl. Spid. Great. Brit. and Irel., and Cambr. Spid. Dorset.

A decidedly scarce spider, and apparently pretty much confined to moorland districts. Taken by Mr Cambridge on the Pentland Hills in June 1861.

Moor above Currie, 22nd March 1893, ♀; Bavelaw Moor, April, ♀; Dalmeny Park, April, ♀; near Rosslyn, 26th July, ad. ♂; Ravensnook Moor near Penicuik, 28th July, two ♀s.

Leptyphantes cristatus, Menge.

Linyphia cristata, Cambr. Spid. Dorset.

Not at all common, but perhaps not unfrequently overlooked from its close resemblance to some of the more abundant species. In Dorsetshire Mr Cambridge takes it in April and May; but, as will be seen, we have obtained adult males in autumn and winter as well as in spring.

Roadside North Morton, Feb., two ad. ♂s; Loganlee (Pentlands), March, two ♀s; The Bush near Rosslyn, Oct., two ad. ♂s; Dreghorn Woods, Nov., six ad. ♂s; Comiston, Nov., ♂ and two ♀s; Kaimes near Liberton, at foot of wall, Dec., two ♂s; Bridge of Allan, Dec., ad. ♂.

Leptyphantes zebrinus, Menge.

Linyphia zebrina, Cambr. Spid. Dorset.

Widely distributed, and common in same situations as the next: adults obtained throughout the year. First added to the Scottish list by Mr H. C. Young, who took it in the neighbourhood of Glasgow in 1878.

Comiston, Jan., two ♀s; by Braidburn, Feb., ad. ♂ and several ♀s; Balerno, Bonaly, Rosslyn, March, a few ♂s, many ♀s; Aberdour, etc., April and May, ♂s and ♀s; Colinton, Dryden, Temple, etc., July, numerous ♂s and ♀s ad.; Kirknewton, Aug., ad. ♂; about Leven (Fife), Aug., many ad. ♂s and ♀s; Glencorse and Balerno, Sept., a few ad. ♂s; Bonaly, Boghall, Scaldlaw (Pentlands), etc., Oct., a number of ad. ♂s and ♀s; Craigmillar, Kaimes, Craiglockhart, Torduff, Nov. and Dec., a number of ad. ♂s and ♀s.

Leptyphantes tenebricolus (Wid.).

Linyphia tenuis + *L. terricola*, Bl. Spid. Great Brit. and Irel.
Linyphia tenebricola, Cambr. Spid. Dorset.

Universally distributed, and exceedingly common among rough grass and other herbage by walls, hedges, banks, etc.: adults throughout the year.

The locality records (45 in number) are too numerous to name in detail; they extend from the Isle of May to Bridge of Allan, and from the shores of the Forth back to the hills. An analysis of these records shows numerous adult ♂s and ♀s for every month of the year—the largest numbers falling into March, July, Oct., Nov., and Dec.; but no doubt this distribution is to some extent accidental. In the adult state, however, the species seems clearly to be more abundant between autumn and spring than between spring and autumn. We have noted young and immature examples in Feb., April, May, July, and Aug.

Leptyphantes ericæus (Bl.).

Linyphia ericæa, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Fairly common, more especially on moors and hillsides covered with heather.

Braids (under whins), Bonaly (under heather), Feb., a few ad. ♀s; Bavelaw Moor, Currie Moor, Bonaly Glen, March, ad. ♂ and several ♀s; Pentlands above Currie, April, two ♀s; Temple, July, ad. ♂; Auchincorth Moor near Penicuik, July, a few ♀s, some imm.; near Leven, Aug., ad. ♂; near Largo, Sept., ad. ♀; Luffness Links, among damp moss, 7th Oct., ad. ♂s and ♀s; Caerketton, Bonaly Glen, Carnethy (Pentlands), Oct., a number of ad. ♂s and ♀s and some young; Pentlands above Boghall, Nov., two ♀s; by Braidburn path, among grass, Dec., two ♂s and a ♀.

Bathyphantes variegatus (Bl.).

Neriene variegata, Bl. Spid. Great Brit. and Irel.
Linyphia variegata, Cambr. Spid. Dorset.

Widely distributed and abundant, especially among heather and on furze in subalpine localities. Adults may be met with practically throughout the year, but they are apparently more numerous in spring and autumn than at other seasons, which would seem to point to the species being double-brooded.

By Braidburn, Braid Hills, Pentlands, Feb., a few ad. ♂s and ♀s; Blackford Hill, Arthur's Seat, Rosslyn, Leadburn, Joppa, Bonaly, Currie Moor, Bavelaw Moss, Kirknewton, Pettycur, March, about fifty ad. ♂s and ♀s; Corstorphine Hill, Balerno, Aberdour, etc., April and May, numerous ad. ♂s and ♀s and a few young; Rosslyn, Arthur's Seat, Thornton, Glencorse, July, Aug., and Sept., a few ♀s; North Morton, Bavelaw, Caerketton, and Scaldlaw (Pentlands), Gullane, etc., Oct. and Nov., numerous ad. ♂s and ♀s.

Bathyphantes concolor (Wid.).

Theridion filipes, Bl. Spid. Great Brit. and Irel.
Linyphia concolor, Cambr. Spid. Dorset.

An abundant spider among grass and other herbage, and under stones about roadsides, plantations, etc., throughout the lowland parts of the district. In Dorsetshire Mr Cambridge finds it during spring and early summer, but with us adults are as common in late autumn and winter as in spring.

At foot of wall, Comiston Road, Jan., two ad. ♂s and a number of ♀s; roadsides south of Edinburgh (Fairmilehead, Hillend, etc.), Feb., several ♂s, numerous ♀s; Craiglockhart Wood, Salisbury Crags, Joppa, Pettycur, etc., March, numerous ad. ♂s and ♀s; Blackford Hill, Corstorphine Hill, Aberdour, etc., April and May, a few ad. ♂s, more ♀s; Seafield, June, a few ♀s; Aberlady, Sept., ad. ♂; Boghall, Bonaly, Balerno, etc., Oct., a few ♂s and ♀s; Colinton, Comiston, Kaimes, Craigmillar, etc., Nov., ♂s and ♀s common, Dec. abundant.

Bathyphantes approximatus (Cb.).

Linyphia approximata, Cambr. Spid. Dorset.

Common among grass, iris, etc., in marshy places. Adult in spring and autumn. Dr Hardy has taken it in Berwickshire.

Marl pit near Davidson's Mains, March, several ad. ♂s; Otterston Loch, April, a few ♀s; Duddingston Loch, May, a few ♀s; Kilconquhar Loch, Sept., numerous ad. ♂s and ♀s; marshy spot near Kirkcaldy, Sept., five ♂s and a ♀; Duddingston Loch, Oct., ♂s and ♀s abundant.

Bathyphantes nigrinus (Westr.).

Linyphia pulla, Bl. Spid. Great Brit. and Irel.
Linyphia nigrina, Cambr. Spid. Dorset.

Widely distributed and fairly common among grass and other herbage. Adults from end of summer to spring.

By Braidburn, Feb., several ♂s and ♀s; near Glencorse Reservoir, March, two ♂s and a ♀ ad., and numerous young; Arthur's Seat and Dalkeith, April, two ad. ♂s and ♀, and another nearly mature; Duddingston, May, ♀; Roslyn, July, a few ad.; Leven, Largo, Raith, Glencorse, Aug. and Sept., a number of ad. ♂s and ♀s; The Bush, Dreghorn, etc., Oct. and Nov., a few ad. ♂s and ♀s, and one young.

Bathyphantes dorsalis (Wid.).

Linyphia claytoniæ, Bl. Spid. Great Brit. and Irel.
Linyphia dorsalis, Cambr. Spid. Dorset.

Widely distributed and common on yew hedges, furze bushes, etc., from spring to autumn. Adult males observed only in spring and early summer.

By Braidburn, Feb., ♂ and three ♀s; Balerno, March, ♀; Raith grounds, on yew hedge, etc., April, several ad. ♂s and immense numbers imm.; Aberdour (on whins), Dalkeith Gardens (on conifers), etc., April and May, abundant, many adult; Roslyn, July, a few ♀s; Leven, Kilconquhar, Raith, Gosford, Aug. and Sept., a few ad. ♀s, numerous young.

Bathyphantes gracilis (Bl.).

Linyphia gracilis + *L. circumspecta*, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widely distributed, but not very common among grass, etc., from autumn to spring or early summer.

Roadsides at Buckstone, Comiston, etc., Jan., a few ad. ♂s; Braid Hills (under furze), and by Braidburn, Feb., two ♂s and two ♀s ad.; Loganlee, March, ♀; Aberdour, April, ♂; Dreghorn, June, ad. ♂; Raith (among reeds), Sept., three ♂s; Luffness Links (among damp grass), and by Duddingston Loch, Oct., five ♂s and three ♀s; Braids, Nov., ♂.

Porrhomma microphthalma (Cb.).

Linyphia microphthalma + *L. incerta* + *L. decens*, Cambr. Spid. Dorset.
Linyphia meadii, F. Cb. (*Ann. Mag. Nat. Hist.*, 1894).[1]

A rare spider, of which a pair (adult male and female, identified by Mr Cambridge) were obtained on Scaldlaw (Pentlands), 17th October 1893. Under the name of *Linyphia decens* it has been recorded from Berwickshire by Mr Cambridge—*vide* his paper in the *Entomologist* for 1877.

Porrhomma egeria, Sim.

Of this species, which is now recorded for the first time as British, a female was taken by Mr Bruce Campbell in Dalmeny Park, 11th March 1893. An adult female was also obtained in the neighbourhood of Rosslyn in July 1893; and on 22nd March 1894 numerous females and one male—all adult—were found running on the top rail of a paling at Murrayfield, immediately to the west of the city. We have to thank Mr Cambridge for the specific determination. We believe this to be the first British record of the species, though we hear from Mr Cambridge that it has also been taken at Cheddar, Somerset, this last spring (1894).

Porrhomma pygmæa (Bl.).

Neriene pygmæa, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Apparently scarce, a few specimens only (some of which Mr Cambridge has seen) having been obtained by beating furze.

Near Balerno, ad. ♂ and ♀, 14th April 1893; again, 12th Sept., ad. ♂; Pendreich, near Bridge of Allan, ad. ♂, and a number of imm. ♂s and ♀s, probably belonging to same species, 31st December.

Porrhomma reticulata (Cb.) = P. adipatum (L. K.).

Linyphia reticulata, Cambr. Spid. Dorset.

This interesting and apparently alpine species may be expected to occur on the tops of some of our higher hills, seeing it has been recorded from the Cheviots and the mountains of Aberdeen and Sutherland. Hitherto, however, we have found it only under stones on the summit of Scaldlaw, the highest point of the Pentlands, where a male and a female, both adult, were taken on 17th October 1893. On the Continent it has only been found among the Alps of France, Switzerland, and the Tyrol.

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[1] We are at a loss to understand why Mr F. P. Cambridge has thought it necessary to bestow a fourth name on a species which he has shown to be already provided with three.

Hilaira uncata (Cb.).

Neriene uncata, Cambr. Spid. Dorset.

Two examples only of this rare spider have been met with, namely, an adult male near Aberdour on 8th April 1893, and an adult female (identified by Mr Cambridge) beside Luffness Marsh, 4th Oct. 1893. Professor Trail obtained it on a mountain in Upper Dee about twenty years ago. Elsewhere it seems to have occurred only in Dorset, Northumberland, and a single locality in central France (Dept. Cantal).

Tmeticus hardii (Bl.).

Walckenaëra hardii, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Of this rare spider an adult male was captured under a stone embedded in seaweed at high-water mark, Jova's Neuk, Aberlady Bay, on 16th Sept. 1893; another, supposed to be of the same species, escaped. Dr Hardy, whose name it bears, found the type-specimen under a stone on Penmanshiel Moor, Berwickshire, in Dec. 1848; and in Sept. 1858 he again obtained specimens in the same locality (*Proc. Berw. Nat. Club*, 1858, p. 95). The only other locality appears to be in the same French department that has yielded the preceding species.

Tmeticus scopiger, Grube.

Linyphia rufa, Cambr. Spid. Dorset.

Widely distributed, but not common; at roots of grass, rushes, heather, etc. Adult in autumn. Has been taken in Berwickshire, Aberdeenshire, and near Glasgow, and is apparently more of a northern than a southern species in Britain. Abroad it appears to range from north-eastern France to Sweden and Siberia.

Ravensnook Moor, near Penicuik, ♀, just after final moult, 28th July; near Wemyss, Fife, ad. ♂ and two ♀s, Aug.; Isle of May, ♀, Aug.; Leven, ♀, Sept.; Balerno, ♀, Sept.; Drumshoreland, two ♀s, Sept.; Luffness, three ♀s, Oct.; Pentlands, near Bavelaw Castle, ♂ and two ♀s, Oct.; Do., above Boghall, two ♀s, Oct.

Tmeticus abnormis (Bl.).

Neriene abnormis, Bl. Spid. Great Brit. and Irel.
Linyphia abnormis + *L. linguata*, Cambr. Spid. Dorset.

Rare, a few specimens only having as yet been met with. It has, however, already been recorded from Scotland, namely, from Paisley (*Entomologist*, 1877, p. 177).

Raith, near Kirkcaldy, ad. ♂, 8th April 1893; Pentlands, above Boghall, under stone, ad. ♀, 23rd Nov. 1893; Drumshoreland, ad. ♀, 13th Sept. 1893 (identified by Mr Cambridge).

Tmeticus rufus (Wid.).

Neriene rubripes, Bl. Spid. Great Brit. and Irel.
Neriene rufa, Cambr. Spid. Dorset.

A scarce species, of which we have obtained, at very varied seasons of the year, one adult male and eight females. It occurs under stones and among grass, etc.

Roadside about four miles south of Edinburgh, ♀, Feb. 1893; between Aberdour and Burntisland, near the Water-Works, ♀, 9th April; by wood about a mile to east of Aberdour, two ♀s, 10th April; Spinkie Den, Leven, ♂ and ♀, 27th Aug.; Bridge of Allan, ♀, 29th Dec.; Craiglockhart Wood, ♀, Feb. 1894; Leadburn, ♀, 17th March.

Tmeticus carpenteri, Cb.

An adult male *Tmeticus*, found under a stone at the back of the "T" wood, Swanston (foot of the Pentlands), on 15th Nov. 1893, and a female obtained in the same locality (and either on the same day or on 20th Oct., we cannot be sure which), are described by Mr Cambridge as new to science, under the above name, in the current volume of *Proceedings of the Dors. Nat. Hist. and Antiq. Field Club* (vol. xv., p. 108, fig. 4, 1894).

Tmeticus reprobus (Cb).[1]

Neriene reproba, Cambr. Spid. Dorset.

Of this very rare and little known spider, we met with an adult male and numerous females beside their egg-cocoons under stones at high-water mark, St Colme Bay, Aberdour, on 9th April 1894. We are indebted to Mr Cambridge for identifying our specimens, which are the first recorded for Scotland. The type-specimen was found under a stone on the coast near Weymouth in April 1879.

Tmeticus huthwaitii (Cb.).

Neriene huthwaitii, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

An adult male taken in Spinkie Den, near Leven, Fife, on 27th Aug. 1893, and two females found under a stone at Loch Leven, Kinross, on 2nd June 1894, are the only examples of this rare spider we have met with in the district. An addition to the Scottish list.

Tmeticus expertus (Cb).

Linyphia experta, Cambr. Spid. Dorset.

This is another rare spider, of which a male and a female (both adult) were taken near Largo, Fife, on 7th Sept. 1893. In Mr Cambridge's "Spiders of Dorset," several examples are said to have been received from Berwickshire, but the precise localities, as given in his paper on "Border" Spiders (*Proc. Berw. Nat. Club*, 1873-75, p. 319), are near Wooler, in Northumberland. The present would therefore appear to be the first record of the actual occurrence of the species in Scotland.

Tmeticus bicolor (Bl.).

Neriene bicolor, Bl. Spid. Great Brit. and Irel.
Linyphia bicolor, Cambr. Spid. Dorset.

Generally distributed, and very common among herbage and under stones about roadsides, hedges, woods, etc. Adults of both sexes from autumn to spring—apparently most abundant in Oct. and Nov.

[1] We believe this spider to be a *Tmeticus*. M. Simon is certainly mistaken in associating it with *Pedanostethus*, for the female has no claw to the palp.

Buckstone Farm, Jan., ♂ and ♀; Braids, Hillend, etc., Feb., a few ♂s, more ♀s; Comiston, Salisbury Crags, Currie, Loganlee, Dalmeny, Mar., one or two ♂s and a dozen ♀s; Aberdour, April, ♂ and two ♀s; Pettycur, June, ♀; Aberlady, Balerno, Loganlee, Sept., several ♂s, more ♀s; Braids, Fairmilehead, Carnethy, etc. (Pentlands), Luffness, Gullane, etc., Oct., numerous ad. ♂s and ♀s, and some hardly mature; Comiston, Swanston, Pentlands, Craigmillar, Nov., numerous ♂s and ♀s; Craiglockhart Hill, North Morton, etc., Dec., a few ♂s and ♀s.

Tmeticus sylvaticus (Bl.).

Neriene sylvatica, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widely distributed, but far from common. Seems to be essentially an autumn spider.

Near Edinburgh, 23rd March 1890, one ad. ♀; Pentlands between Glencorse and Currie, ad. ♀, Drumshoreland Moor, ad. ♂, and Luffness, ad. ♀, all Sept. 1893; Swanston Hill, several ♂s, Scaldlaw, ♂ and ♀, and Luffness Links, ♂, all Oct. 1893; Ravelrig, near Balerno, Nov., one ♂.

Tmeticus prudens (Cb.).

Linyphia prudens, Cambr. Spid. Dorset.

An adult male—which Mr Cambridge has identified—of this rare spider was found on the Pentlands, beneath a stone lying close to the wall at the top of the pass between Carnethy and Scaldlaw, on 17th Oct. 1893. The species was obtained in Berwickshire by Dr Hardy about twenty years ago. It occurs in Dorset and on the French shores of the Mediterranean.

Micronata fuscipalpis (C. L. K.), Cb.

Neriene flavipes + *N. gracilis*, Bl. Spid. Great Brit. and Irel.
Neriene fuscipalpis, Cambr. Spid. Dorset.
Micronata rurestris, C. L. K. (*fide* Simon).[1]

Generally distributed and common. Adults practically throughout the year, but most abundant in spring and autumn.

Braids, Craiglockhart, etc., Feb., ♂s and ♀s; Caerketton, Currie Moor, and summit of Carnethy (Pentlands), under stones, March, numerous ♂s and ♀s; Murrayfield, on paling, March, numerous ♂s and ♀s; Aberdour and Braid, April, a few ♂s; Kirknewton and Blackford, May, two ♂s; Morningside, Dreghorn, Kinross, etc., June, a few ad. ♂s; Colinton and Rosslyn, July, a few ♂s; Leven, Aug., many ♂s and ♀s; Glencorse, Gosford, Kilconquhar, Sept., a number of ♂s and ♀s; North Morton, Swanston, Bonaly Glen, Aberlady, Gullane, Oct., many ♂s and ♀s; Braid Hills, on iron fence, Nov., five ♂s and one ♀.

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[1] M. Simon believes that *M. fuscipalpis*, C. L. K., is another species. On this we can form no opinion, but prefer to follow the specific nomenclature of Mr Cambridge.

Microneta innotabilis (Cb.).

Neriene innotabilis, Cambr. Spid. Dorset.

Of this scarce little spider nine specimens only—all adult females, several of which Mr Cambridge has seen—have been recognised. New to Scotland. It appears to be a winter species with us.

Craiglockhart, 13th Dec. 1892, ♀; Bonaly Glen, 12th Oct. 1893, ♀; Scaldlaw, 14th Oct., four ♀s; Bridge of Allan, 29th Dec., ♀; Leadburn, 17th March 1894, two ♀s.

Microneta conigera (Cb.).

Neriene conigera, Cambr. Spid. Dorset.

Rare, two adult males obtained by beating furze near Belstane, Kirknewton, 18th June 1894, being the only examples we have as yet detected. Is recorded for Berwickshire and Aberdeenshire, and has been taken by us in Inverness-shire.

Microneta viaria (Bl.).

Neriene viaria, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Not common, but taken on several occasions in widely separated localities, and adult at all seasons of the year.

Aberdour, by road leading to Water-Works, April, two ♂s and four ♀s; again, in wood about a mile to east of village, April, three ♂s and numerous ♀s; Spinkie Den, Leven, Aug., five ♂s and two ♀s; Aberlady, Sept., ♂; Scaldlaw, Oct., two ♀s; Bridge of Allan, Dec., ♂.

Sintula diluta (Cb.).

Neriene diluta + *N. demissa*, Cambr. Spid. Dorset.

Among a number of Theridiids collected on 16th Oct. 1893 among moss under juniper bushes on the Pentlands above Swanston, Mr Cambridge has detected an adult male of this minute spider. It is an addition to the Scottish list.

Gongylidium rufipes (Sund.).

Neriene munda, Bl. Spid. Great Brit. and Irel.
Neriene rufipes, Cambr. Spid. Dorset.

Apparently local and rare. Has been taken near Glasgow, June 1878.

Gosford, on shrub, 17th Sept. 1893, one ♀, not quite mature; Luffness, on buckthorn, 6th Oct., ad. ♀.

Gongylidium dentatum (Wid.).

Neriene dentata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Common in marshy places, about the roots and stems of iris and other plants, in spring and autumn.

Aberdour and Otterston Loch, April, several ad. ♂s and one ♀; Duddingston Loch, May, a few ♀s; Rosslyn, July, two ♀s; Kilconquhar Loch, Sept., many ad. ♂s and ♀s; Raith, Sept., ♂ and three ♀s; Balerno, Sept., two ♀s; Luffness Marshes, 4th Oct., a number of ♂s and four ♀s ad., and many ♀s imm.; Duddingston Loch, 11th Oct., numerous ad. ♂s and ♀s.

Gongylidium fuscum (Bl.).

Neriene fusca, Bl. Spid. Great. Brit. and Irel.
Neriene agrestis, Cambr. Spid. Dorset, p. 115; see also pp. 486 and 574.

Rare, a few males only recognised. Recorded from Berwickshire in 1875.

Rosslyn, 22nd July 1893, a few ♂s (identified by O. P. C.); near Largo, 7th Sept., one ♂ ad.; Luffness Links, 5th Oct., an ad. ♂.

Gongylidium agreste (Bl.).

Neriene agrestis, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset, p. 486.

Apparently rare, the only specimens identified being two adult males and two females obtained among sand on Luffness Links, 5th Oct. 1893. Sent to Blackwall from Berwickshire by Dr Hardy many years ago.

Gongylidium retusum (Westr.).

Neriene retusa, Cambr. Spid. Dorset.

Another rarity, obtained on three occasions only. Has, however, already been recorded from other parts of Scotland.

Near Penicuik, 28th July 1893, an ad. ♂; Luffness Links, among sand, 5th Oct., ad. ♂ (O. P. C.).; Do., on sand, 16th June 1894, ad. ♂.

Gongylidium morum, Cb.

This species rests as yet on a single adult female found at Aberlady in September 1893, and described by the Rev. O. P. Cambridge as new to science in *Ann. Scot. Nat. Hist.* for Jan. 1894, p. 21.

Tiso vagans (Bl.).

Neriene vagans, Bl. Spid. Great Brit. and Irel.
Neriene longimana, Cambr. Spid. Dorset.

Rare, but obtained in several widely separated localities. Mr Cambridge, who took the species near Edinburgh in 1861, looks upon it as of more frequent occurrence in Scotland than in the south of England. Adults from spring to autumn.

Salisbury Crags, 7th March 1893, ad. ♂ ; Rosslyn, 27th July, ad. ♂ and ♀ ; Aberlady, 30th Sept., ad. ♂ ; Luffness Links, among grass, 7th Oct., ad. ♂ (O. P. C.); foot of Carnethy, near Silverburn, 24th March 1894, ad. ♂.

Erigone atra, Bl.

Neriene longipalpis, Bl. Spid. Great Brit. and Irel.
Neriene atra, Cambr. Spid. Dorset.

Abundant everywhere. Adults occur at all seasons, but are especially numerous in spring and autumn. On sunny days during Nov. and Feb. the wall tops for miles out from Morningside are alive with the present species and *Diplocephalus frontatus;* to them also is mainly due the gossamer, which we occasionally see spread over the fields, making them appear in the light of the morning or the evening sun like the surface of a lake moved into a ripple or ice-bound, according as a gentle breeze or a still atmosphere prevails.

Wall tops and palings around Edinburgh, Feb. and March, ad. ♂s and ♀s abundant; Braid, Feb., under overhanging bank, a few ♂s; Oxgangs, 5th Feb. 1893, ploughed field entirely covered with gossamer, which must have been made in the course of a few hours during the early part of the day, yet by three o'clock in the afternoon it was with difficulty that half a dozen of the spiders (♂s and ♀s) could be got for identification; Clubbiedean, Pettycur, etc., March, common; Aberdour, Balerno, Glencorse, April, ad. ♂s and ♀s; Kinross, 2nd June, ad. ♂s, ♀s com., and many cocoons (these contained on the average about fifteen eggs, some of which were hatching) attached to the undersides of stones—one stone had fifty-two on it; Seafield, etc., June, a few ad. ♂s; Hillend, Rosslyn, Temple, July, a few ad. ♂s and one ♀; Leven, Aberlady, etc., Aug. and Sept., numerous ♂s and ♀s ad.

and imm.; top of Caerketton (Pentlands), 20th Oct., two ad. ♂s; wall to
and railings around Edinburgh, Balerno, etc., Nov., many ♂s and ♀s.

Erigone longipalpis (Sund.).

Neriene longipalpis, Cambr. Spid. Dorset.

Probably widely distributed, but as a rule far from common.

On wall beyond Fairmilehead, Feb. 1893, two ♂s and two ♀s ad.; near Aberdour, April, two ♂s; Luffness Links, on sandhills, 1st June 1890, numerous ♂s and ♀s; Gullane, Oct., one ♂.

Erigone promiscua (Cb.).

Neriene promiscua, Cambr. Spid. Dorset.

Apparently rare in the district, a single specimen—an adult male—obtained near Rosslyn on 26th July 1893, and since identified by Mr Cambridge, being the only one as yet detected. Has been taken in Perthshire and Aberdeenshire.

Erigone dentipalpis (Wid.).

Neriene dentipalpis, Cambr. Spid. Dorset.

Widely distributed and fairly common, especially in spring and autumn, but nothing like so abundant as *E. atra*.

Salisbury Crags, under stones, March, a few ad. ♂s and ♀s; Torduff Reservoir (on railing) and near Loganlee, March, a few ♂s; Murrayfield, on paling, March, a few ♂s; Aberdour, April, several ♂s, more ♀s; Rosslyn, July, a number of ♂s; Balerno and Kilconquhar, Sept., several ♂s; Bonaly Glen and Scaldlaw, Oct., a few ♂s and ♀s; Luffness Links, among sand, Oct., numerous ♂s and ♀s.

Lophomma punctata (Bl.).

Walckenaëra punctata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Rather local, being partial to swampy places, and not very plentiful. As yet we have only detected adult males in autumn.

Duddingston, May, a few ad. ♀s; Kilconquhar Loch, Sept., a number of ad. ♂s and ♀s; Luffness Curling Pond and in ditches on the Links, Oct., a good many ♂s and ♀s; Duddingston Loch, Oct., several ♂s and ♀s, one ♂ imm.

Dicymbium nigrum (Bl.).

Neriene nigra, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Probably widespread, but not plentiful. Mr Cambridge finds it in April and May, but we have met with it only in autumn.

North Morton, Balerno (on wall), Swanston Hill, Aberlady, Oct., half a dozen ad. ♂s and as many ♀s; Braid and Blackford Hills (on walls and palings), Morton (at foot of wall), Nov., five ♂s and two ♀s.

Gonatium rubens (Bl.).

Neriene rubens, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Generally distributed and very common. Adult males obtained from end of summer to winter; females practically throughout the year, but most abundant from autumn to spring.

Buckstone Farm, Jan., ♀; Blackford Hill, Braids, Comiston, Hillend, Bonaly Glen, etc., Feb., many ♀s; Woodhouselee, Loganlee, Currie, Balerno, etc., March, many ♀s; Braid Hills, Aberdour, etc., April, several ♀s; Kirknewton, May, ♀; Dreghorn, June, ♀; Rosslyn, Penicuik, Edgelaw, July, several ♂s, more ♀s; Leven, Wemyss, etc., Aug., numerous ♂s and ♀s; Loganlee, Sept., a few ♂s; The Bush, Pentlands above Boghall, Scaldlaw, Oct., a number of ♂s and ♀s; Kaimes, Bridge of Allan, etc., Dec., ♂s and ♀s.

Gonatium rubellum (Bl.).

Neriene rubella, Bl. Spid. Great Brit. and Irel.
Neriene isabellina, Cambr. Spid. Dorset.

Probably widely distributed and fairly common, but not nearly so abundant as the last. Males adult in summer and autumn.

Kate's Mill, near Colinton, Feb., ad. ♀; Arthur's Seat, April, ♀; Rosslyn and Temple, on young firs, etc., July, many ad. ♂s and ♀s and some imm.; Kate's Mill, July, ♂s and ♀s; Kirknewton, Aug., ♀; Balerno, Sept., ♂ not quite mature.

Gonatium bituberculatum (Wid.).

Neriene bituberculata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widely distributed but not common; partial to marshy places. The males are adult in spring and summer.

Marl pit near Davidson's Mains, March, several imm.; Duddingston Loch, May, ad. ♂ and ♀; swamp near Doune, May, ad. ♂ and ♀; Loch Leven, June, ad ♂; Rosslyn, July, ♀; Kirknewton, Aug., three ♀s; near Leven, Sept., ♀; Luffness Marshes, Oct., ♀.

Dismodicus bifrons (Bl.).

Walckenaëra bifrons, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Apparently rare; adult about the beginning of summer. Near Kirknewton on furze, 18th May 1894, two adult males and several females; Dreghorn, on hedge, 26th June, adult male and female.

Diplocephalus cristatus (Bl.).

Walckenaëra cristata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widespread, but not very common; adult from autumn to spring. Behind grass at foot of a wall is a favourite habitat.

Fairmilehead, Feb., numerous ad. ♂s and ♀s; Rosslyn and Balerno, March, two ♂s and three ♀s; Fairmilehead, Bonaly, Aberlady, Gullane, Oct., numerous ♂s and ♀s; Craigmillar, Nov., ♂; Greenbank, Dec., four ♂s and six ♀s.

Diplocephalus frontatus (Bl.).

Walckenaëra frontata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Very generally distributed and abundant, running on fences and wall-tops on bright days from autumn to spring. In Dorset Mr Cambridge finds it in May and June; with us, however, it is anything but a summer spider. The fact that four records, which refer almost entirely to adult specimens, fall very largely into March and October, suggests that the species is probably double-brooded. Immature examples noted in Jan., Feb., March, and Nov.

Comiston, etc., Jan., several ad. ♂s and ♀s and a few young; Braid, Hillend, etc., Feb., a number of ♂s and ♀s, some imm.; Greenbank, Rosslyn, Woodhouselee, Bonaly Glen, Torduff Reservoir, Currie, Balerno, Kirknewton, Addiewell, Murrayfield, Joppa, etc., on wall-tops, palings, etc., March, adults of both sexes very numerous—some immature examples also noted; Aberdour, etc., April, some ad. ♂s and ♀s; Leven, Luffness, etc., Sept., a good many ad. ♂s and ♀s,—on 25th a grass field at Luffness Mains was so completely covered with gossamer, on which this and one or two other species were found, as to give it the appearance of a frozen lake; Comiston Road (on wall-top), North Morton, The Bush, Boghall, summit of West Kipp (Pentlands), Bonaly, Balerno, Gullane, etc., Oct., adults of both sexes very abundant; Comiston, Dreghorn, Braids, Nov., many adults and a few imm.; Greenbank, Craiglockhart, Bridge of Allan, Dec., a few ad. ♂s and ♀s.

Typhocrestus digitatus (Cb.).

This spider, of which we have obtained but a few specimens on the shores of the Forth in East Lothian, is an addition to the British fauna. It seems scarce on the Continent, though it has been taken at stations from the shores of the Bay of Biscay in North-west France to Marseilles on the Mediterranean, at Nuremberg in Silesia, and also in the Swiss Alps at the Great St Bernard. Mr Cambridge has recently redescribed the species from one of our specimens (*Ann. Scot. Nat. Hist.*, 1894, p. 19).

Luffness Links, near Aberlady, Sept. 1893, an ad. ♂; Do., 5th Oct., another ad. ♂; Links behind Gullane, 9th Oct., two ad. ♂s.

Entelecara erythropus (Westr.).

Walckenaëra erythropus, Cambr. Spid. Dorset.

Not common, about a dozen specimens only having as yet been obtained by us, and these all in inland localities. In June 1861 Mr Cambridge found two adult males on a wall at the foot of the Pentlands above Currie, and described them as new to science under the name of *Walckenaëra borealis*. Apparently a summer spider.

Kate's Mill, near Colinton, 17th July 1893, ad. ♂; Rosslyn, 25th July, ad. ♂ and ♀; Kirknewton, 9th Aug., ad. ♂; Dreghorn, on hedge, 26th June 1894, ad. ♂; Braid Hills, on furze, 30th June, ad. ♂ and half dozen ♀s.

Aræoncus humilis (Bl.)

Walckenaëra humilis, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

We have only met with this minute spider on one occasion, namely, on 9th Oct. 1893, when a few males and females were obtained among "marram" grass on the sandhills behind Gullane. In June and July 1861 Mr Cambridge found a number of adult males running on the pavements in the streets of Edinburgh.

Aræoncus crassiceps (Westr.).

Walckenaëra crassiceps + *W. affinitata*, Cambr. Spid. Dorset.

A single specimen (an adult male) of this very rare spider was obtained on the margin of Loch Leven, close to Kinross, on 2nd June 1894,—an addition to the Scottish list.

Troxochrus hiemalis (Bl.).

Walckenaëra hiemalis, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Apparently very uncommon, a pair (adult male and female) found among dead leaves, etc., in a wood about a mile to the north-east of Aberdour, Fife, on 10th April 1893, being the only examples as yet detected. An addition to the Scottish list.

Lophocarenum parallelum (Bl.).

Walckenaëra parallela, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Another rarity, of which an adult male, identified by Mr Cambridge, was found among grass on Luffness Links, East Lothian, on 6th Oct. 1893.

Lophocarenum nemorale (Bl.).

Walckenaëra nemoralis, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

On and under furze bushes, not common. Our specimens were taken in early spring, but according to Mr Cambridge it is also to be found in autumn.

Braid Hills, under furze bushes, several occasions during Feb. 1893, three ad. ♂s and eight ♀s.

Peponocranium ludicrum (Cb.).

Walckenaëra ludicra, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

On furze in spring and early summer, not uncommon.

Braid Hills, Feb. 1893, two ad. ♀s and numerous imm. ♂s and ♀s; again, 25th April, two ♂s just mature, and many ♀s; near Kirknewton, on furze, May 1894, three ad. ♂s and many ♀s; Swanston, etc., June, ad. ♀s common.

Cnephalocotes curtus, Sim.

On 5th Oct. 1893, four or five adult males and about a dozen females of this most interesting addition to the British fauna, were found among sand at the roots of "marram" grass on the east side of Aberlady Bay. Our identification has been confirmed by Mr Cambridge. The species is recorded by M. Simon from Martigues, near the mouth of the Rhone, in France; Arbucias, Catalonia, in Spain; and Alexandria, in Egypt. The occurrence of such a characteristic Mediterranean species on the shores of the Firth of Forth, opens up some interesting problems in animal distribution.

Plæsiocræerus permixtus (Cb.).

Walckenaëra permixta, Cambr. Spid. Dorset.

In swampy places, widely distributed but not very common. We have as yet taken it only in late summer and autumn, which is the season when it occurs in France, according to M. Simon, but Mr Cambridge has found it in Dorset in May.

Temple, 27th July, an ad. ♂; Drumshoreland, Sept., ♂; near Kirkcaldy, Sept., ♂ and two ♀s; marshy spots, Luffness Links, Oct., a dozen ♂s and several ♀s; Duddingston Loch, Oct., a dozen ♂s and ♀s.

Plæsiocræerus fuscipes (Bl.).

Walckenaëra fuscipes, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widely distributed and fairly common in spring and autumn.

Braid Hills, Feb., ♂; Rosslyn, Currie Moor, Kirknewton, Pettycur (Fife), March, a number of ad. ♂s and a few ♀s; Torduff Reservoir, 29th March 1893, ♂s and ♀s abundant on railing; Aberdour, Otterston, Hopetoun, April, several ♂s; Blackford Hill, and Pentlands above Hillend, May, two ♂s; Swanston, Luffness Links, Gullane, Oct., a few ♂s; Dreghorn Woods, Nov., ♂ and ♀.

Plæsiocræerus alpinus (Cb.).

This species, of which we have taken specimens in several localities around Edinburgh, and which is recorded now for the first time as British,[1] appears to be a characteristically mountain form. It was discovered in 1865 by Rev. O. P. Cambridge, at Bruck-am-Muir, in the Styrian Alps, and has also been taken in the Tyrolese Alps, at an elevation of 6000 feet. Its only other known locality is in the Maritime Alps of Southern France, where M. Simon has found it. Mr Cambridge has confirmed our identification.

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[1] While this paper is passing through the press, Rev. O. P. Cambridge records this species in Proc. Dorset Nat. Hist. and Ant. Field Club, vol. xiv.

Craigmillar Castle, behind grass at foot of wall, 28th Nov. 1892, two ♂s and four ♀s ad.; Fairmilehead, in similar situation, 16th Dec. 1892, two ♂s and two ♀s; Pentlands above Hillend, under stone, 24th Feb. 1893, ♂ and ♀; Do., 19th May 1894, ♂; roadside about a mile north of Aberdour, 9th April 1893, ♂; Temple, 27th July 1893, ♂.

Tapinocyba mitis (Cb.).

Mr Cambridge informs us that among a number of spiders we sent him from the Pentlands above Swanston, where they were collected on 16th Oct. 1893, he finds an adult female of this minute species. We believe the only other recorded British habitat for it is Bloxworth, in Dorsetshire. The female of the species was described in *Ann. and Mag. Nat. Hist.* for 1882 (ser. 5, vol. ix., p. 8), and the male in *Proc. Dors. Nat. Hist. and Antiq. Field Club*, 1883 (vol. xiv., p. 159).

Caledonia evansii, Cb.

This species rests as yet on a single specimen, an adult male, found among moss under heather on the Pentland Hills, on 14th Sept. 1893; the exact locality is a little above the shepherd's cottage, by the path leading from Glencorse Reservoir to Currie. Mr Cambridge's description and figure of the species will be found in the *Annals of Scottish Natural History* for January 1894, p. 21.

Minyriolus pusillus (Wid.).

Walckenaëra pusilla, Cambr. Spid. Dorset.

Of this exceedingly minute spider, which is only about $\frac{1}{22}$ of an inch in length, we found two adult males and several females (some of which Mr Cambridge has seen) among débris under heather near the top of Bonaly Glen, on 12th Oct. 1893. We know of only one previous Scottish record, namely from Inverury in Aberdeenshire.

Wideria antica (Wid.).

Walckenaëra antica, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Widely distributed but not common. Mr Cambridge finds it in May and June; we have found it, however, chiefly in autumn. In France, M. Simon finds it both in spring and autumn.

Leadburn, March, ♀; near Kilconquhar, Sept., ♀; Pentlands, by path leading from Glencorse Reservoir to Currie, 14th Sept., ♂ just after final moult; Luffness Links, on buckthorn, Oct., two ♀s; Gullane, at foot of wall, Oct., ♀; Bonaly Glen, Oct., ♀; Swanston Hill, Oct., ad. ♂.

Walckenaëra nudipalpis (Westr.).

Very rare, an adult male found among moss in an old fir plantation, Luffness, East Lothian, being the only specimen we have yet discovered. It has been taken in Berwickshire, and near Paisley.

Walckenaëra obtusa, Bl.

Another rarity, of which a single specimen, an adult male, was taken among moss and heather on the Pentlands (between Glencorse Reservoir and Currie Moor), on 14th Sept. 1893. Has been found by Dr Hardy in Berwickshire.

Walckenaëra acuminata, Bl.

This singular species, the adult male of which carries his eyes on a tall slender process, reminding one of a miniature lighthouse, arising from the fore-part of his head, is widely distributed, and fairly common under stones and among moss, etc. Adult males in autumn and winter.

By Braidburn, Comiston, Bonaly Glen, Balerno, Loganlee, Kirknewton, Salisbury Crags, March, a number of ad. ♀s, singly or at most two together; Aberdour, April, ♀; Wemyss (Fife), Aug., imm. ♀; Luffness, in old fir plantation, Sept., two ad. ♀s; Luffness Links, Sept., three ad. ♂s; Bonaly Glen, Oct., ♀; near Bavelaw Castle, Oct., three ♂s; Pentlands between Boghall and Swanston, Oct., three ♂s and three ♀s; Pentlands above Hillend, Nov., ♀; Swanston, Nov., ♂ and ♀; Bridge of Allan, Dec., two ♂s.

Prosopotheca monoceros (Wid.).

Walckenaëra monoceros, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Of this very rare spider, which is now recorded for the first time as Scottish, a single example, an adult male, was taken at the foot of a wall behind the village of Gullane in East Lothian on 9th Oct. 1893.

Cornicularia cuspidata (Bl.).

Walckenaëra cuspidata, Bl. Spid. Great Brit. and Irel., and Cambr. Spid. Dorset.

Probably widely distributed, but seemingly rare. Adults in spring and autumn. Has been taken in Berwickshire and near Castle Douglas.

Rosslyn Glen a little below the castle, March 1893, three ♂s; by roadside above Balerno, March, three ♀s; Loganlee, Pentlands, March, ♂ and ♀; near Largo, Sept., ♂.

Ceratinella brevis (Wid.).

Walckenaëra depressa, Bl. Spid. Great Brit. and Irel.
Walckenaëra brevis, Cambr. Spid. Dorset.

Seemingly widely distributed but not common. Appears to have a preference for heaths and moors. Adults in spring and autumn.

Bavelaw Moss, among heather, March, ♀; Arthur's Seat, April, ♀; Pass of Leny, May, ad. ♂; Bavelaw Moss, Sept., ad. ♂; Bonaly Glen, Oct., ♂ and ♀; Scaldlaw (Pentlands), Oct., two ♀s; North Morton, Oct., ♀; Luffness Links, among cut grass, Oct., an ad. ♂ and numerous imm. ♂s and ♀s; Arthur's Seat, June 1861 (Mr Cambridge).

Ceratinella brevipes (Westr.).

Walckenaëra brevipes, Cambr. Spid. Dorset.

Apparently even less common than the last, to which it is closely allied. Has been taken near Aberdeen. Mr Cambridge has seen some of our specimens.

Near the Moor above Currie, 22nd March 1893, ad. ♂; Arthur's Seat and Salisbury Crags, March, a few ♂s; among stones on hillside above Lothianburn, 16th Oct., an ad. ♂ and many imm. ♂s and ♀s.

Maso sundevallii (Westr.).

Neriene sundevallii, Cambr. Spid. Dorset.

Rare, and now recorded for the first time as Scottish.

By wood about a mile north-east of Aberdour, 10th April 1893, two ♀s; Bavelaw Moss, 14th April, ♀; Rosslyn, 27th July, ad. ♂ (shown to O. P. C.); Bridge of Allan, 29th Dec., ♀.

Pachygnatha clerckii, Sund.

This well-marked spider is widely distributed and common in the district in beds of iris, carex, and other plants growing in marshy places. Adults may be obtained at most times of the year.

By Braidburn, Feb. and March, three ad. ♂s and a number of ♀s; Otterston Loch, April, ♀; Luffness Links, May, a few ad. ♂s and ♀s; Duddingston Loch, May, ♀; Loch Leven, June, ad. ♂ and ♀; Rosslyn, July, ♀; Kilconquhar, among reeds, Sept., many ad. ♂s and ♀s; Drumshoreland, Sept., a few ♀s; Luffness Marshes, among iris, Oct., ad. ♂s and ♀s abundant; Duddingston Loch, Oct., many ♂s and ♀s; Greenbank, Dec., ad. ♂.

Pachygnatha degeerii, Sund.

Generally distributed and abundant practically throughout the year. Adult males chiefly during spring and autumn.

Comiston, Balerno, Habbie's Howe (Pentlands), Kirknewton, Pettycur, March, ad. ♂s and ♀s common; Donibristle, Burntisland, Arthur's Seat, April, a few ♂s and ♀s; Aberlady, etc., May and June, a few ♀s; Fairmilehead, 1st July, ad. ♂; Rosslyn Castle, among cut grass, 25th July, many imm. and young; Isle of May, 17th Aug., ♂ (just mature) and ♀; Leven, Elie, etc., Aug. and Sept., numbers both ad. and imm.; Balerno, Drumshoreland, Luffness, Sept., many ad. ♂s and ♀s; Gosford, Sept., imm. ♀; Oxgangs, Boghall, Bonaly, Oct., ♂s and ♀s common; Bridge of Allan, Dec., ♀; etc.

"**Walckenaëra bicolor,** Bl."

In June 1861, Mr Cambridge found an example (an adult male) of this minute spider under a stone on Arthur's Seat. Unfortunately the type has been lost, and it is next to impossible to say now where it ought to be placed in the systematic list, or to which genus it should be assigned. We have, therefore, thought it best to insert it under its original name, at the end of the Theridiidæ.

Family **EPEIRIDÆ.**

Meta segmentata (Clk.).

Epeira inclinata, Bl. Spid. Great Brit. and Irel.

Generally distributed and very abundant, fixing its orbicular webs on all sorts of bushes and herbage. Adults in spring and early summer, and again in autumn, when they are far more numerous. The spring examples are generally regarded as smaller than the autumn ones, but we have taken as fine specimens in May as in harvest-time, and as small ones in Oct. as during the first half of the year. On a sunny forenoon, after a night of heavy rain, it is most interesting to watch them spinning fresh snares, which they do in a very methodical and rapid manner. We have seen one of these beautiful webs constructed within an hour. The silken egg-cocoons, of which each female makes several, are placed under stones, in crevices in walls, etc., and contain about 80 or 90 eggs—the exact numbers in six instances were 78, 79, 83, 85, 88, 88.

The following is an analysis of our records, leaving out the localities, which are very numerous, and range over the whole district:—March, ad. ♂ and a few imm. ♀s; April, a number of ad. ♀s and some very young; May, a few ad. ♀s and some very young; June, a number of young, some very small; July, imm. and young examples common; Aug., adults and imm. examples abundant; Sept., adults very abundant—some fine colour-varieties; Oct., adults abundant, and some very young,—18th, ♀ under stone beside eight egg-cocoons; Nov., a number of ♂s and many ♀s; Dec., a few ♀s.

Meta merianæ, Scop.

Epeira antriada + *E. celata*, Bl. Spid. Great Brit. and Irel.

Widely distributed and fairly common, placing its snare under overhanging banks, detached pieces of rock, and thick ivy, or in the mouths of caverns, drains, etc. Adults in spring and early summer, and again in autumn.

By Braidburn, Feb. and March, five ♂s and six ♀s ad., and a number of young; Rosslyn Glen, March, ad. ♂ and two ♀s; Do., July, several imm.; Woodhouselee, Currie, Balerno, March, a number, mostly quite young; Aberdour, Raith, etc., April, a few adult, others young; Colinton, Edgelaw, and Temple, July, a few young ♀s; Leven, Kirknewton, etc., Aug., two ad. ♂s and several imm.; etc.

Tetragnatha extensa, L.

This easily recognised species—which occurs in the adult state during summer on bushes and herbage in the vicinity of ponds and ditches—appears to be very local here.

Raith, on yew bushes by the lake, 8th April 1893, ad. ♀ and several imm. ♂s and ♀s; Do., by ditch above the lake, Sept., a few imm. ♀s; Keilsden, near Largo, Sept., one young ♀; Gosford, on yews by the ponds, Sept., ad. ♀ and many young examples; Luffness, Sept., two young ♀s.

Cyclosa conica (Pall.).

Epeira conica, Bl. Spid. Great Brit. and Irel.

Very rare, a single example—a male not quite mature—shaken off a young conifer in Gosford grounds, East Lothian, on 17th Sept. 1893, being the only one as yet detected. Has been taken in Aberdeenshire, and also in Banffshire, by Professor Trail.

Zilla x-notata (Cl.).

Epeira similis, Bl. Spid. Great Brit. and Irel.

Very common in all the towns and villages along the shores of the Firth of Forth, but apparently very local inland. Constructs its snares in the angles of doors and windows, under the eaves of buildings, and on palings, walls, etc. Pairs in Aug. and Sept.; the males then disappear, but many of the females remain by their egg-cocoons till they are killed off by the frosts of winter. In greenhouses, where it is not uncommon, we have seen adult females in spring. It is a nocturnal, or at least crepuscular spider, seldom leaving its den during the daytime. In the twilight one may be seen on every snare busy devouring some unfortunate insect. Occasionally a pair, male and female, may be observed on the same web.

Greenhouses in Edinburgh Botanic Garden and in Dalkeith Gardens, April, a few ♀s, and many very young; East Wemyss, Leven, Largo, Elie, Kilconquhar, Aug., ♂s and ♀s abundant, both ad. and imm.; Leven, Kirkcaldy, Aberlady, East Linton, etc., Sept., ad. ♂s and ♀s abundant; Duddingston, etc., Oct., a few ♀s beside their egg-cocoons; Morningside and Craiglockhart, Nov., a few ♀s by their eggs; on rock at Duddingston Loch, 31st Dec., ♀ all but dead.

Zilla atrica (C. L. K.).

Epeira calophylla, Bl. Spid. Great Brit. and Irel.

Widely distributed and abundant, making its snares on whins and other low bushes, and only occasionally on rocks, walls, and palings. Pairs in Aug. and Sept.

Luffness, 16th June, a few young; Fairmilehead, etc., July, many young; Arthur's Seat, 9th Aug., ad. ♀, and numerous imm. ♂s and ♀s; Largo, Leven, etc., Aug., many ♂s and ♀s, both ad. and imm. (some on fences); Isle of May, on rocks, Aug. and Sept., several ad. ♂s and many ♀s, all rather darker coloured than usual; road near Glencorse Reservoir (Pentlands), Aberlady, Drem, Tyninghame, Kennoway, Kilconquhar, etc., Sept., adults abundant; farm at Balerno (on outhouse), Oct., ad. ♂ and several ♀s; Craiglockhart (on wall), Torduff, Nov., a number of ♀s beside their egg-cocoons; Blackford Quarry, Dec., ♀; Bridge of Allan, Jan., ♀.

Epeira cucurbitina, Cl.

This pretty bright-green spider is far from common around Edinburgh, where it seems to be confined to ornamental shrubs and conifers in large gardens and pleasure-grounds. In summer, when it is adult, we have found it more readily in the Highlands (Callander, Kingussie, Aviemore), and then on young pines on the outskirts of woods and plantations.

Donibristle, near Aberdour, on *Wellingtonia*, April, several young and imm. ♀s; Raith grounds, on yew, April, young ♀; Hopetoun, on yew, April, imm. ♀ and young ♂; Gosford grounds, on ornamental fir, a number very young in Sept., adults in June.

Epeira diademata (Cl.).

Epeira diadema, Bl. Spid. Great Brit. and Irel.

This large and handsome species, popularly known as the "garden spider," is widely distributed and common in the district. It is not, however, so much an inhabitant of gardens as of wild uncultivated localities. Pairs about harvest-time. The eggs, to the number of several hundred (we have counted 467 and 544), are deposited in autumn in a large round cocoon of yellow silk, but do not hatch, as far as we have observed, till the following April or May—the young apparently not reaching maturity till Aug. or Sept. of the succeeding year. We have never observed adults in spring or early summer, which would seem to indicate that they do not survive the winter. Young hatched in the end of April and beginning of May, and placed in a fern-case, were not observed to have formed orbicular snares till about the middle of June.

Bonaly Glen and Loganlee (Pentlands), Pettycur Links, March, several young ♀s; Braid Hills, Aberdour, April, a number about half-grown; Kirknewton, etc., May, a few imm.; Braids, June, imm. ♂s and ♀s and some very young; Rosslyn, Penicuik, Edgelaw, West Linton, July, a good many imm. and young; Arthur's Seat, Braids, Thornton, etc., Aug., ad. ♂s and ♀s, and imm. examples common; Glencorse (Pentlands), Long Yester and Tynefield (East Lothian), Leven, Largo, etc. (Fife), Sept., adults and young examples common; Bonaly, etc., Oct., a few young ♀s.

Epeira agalena, Walck.

Rare, the only examples we have found being two males and a female, well grown but immature, and a number of smaller specimens beaten from a young conifer in Gosford grounds, East Lothian, on 17th and 20th Sept. 1893. Has been taken in Perthshire by Mr Morris Young, and at Aviemore, in Inverness-shire, by ourselves.

Family **THOMISIDÆ.**

Xysticus cristatus (Cl.).

Thomisus cristatus, Bl. Spid. Great Brit. and Irel.

Universally distributed and abundant. Adults of both sexes are common from March to June; the males then practically disappear, but the females remain in evidence for some time longer, and are to be found occasionally in every month of the year. Young and immature examples are abundant in autumn and early spring. Females appear always to be much more numerous than males.

The following is an analysis of our data, leaving out the localities, which are very numerous, and range from the Isle of May to Stirling, and from the shores of the Forth to the tops of the highest hills:—Jan., several imm. and young; Feb., numerous ♀s and a good many ♂s, a few of the former ad., the others imm. and young; March, many ♀s ad. and imm., and a few imm. ♂s; April, ad. ♀s common, and several ad. ♂s, also a number of imm. ♀s and some very young; May, a number of ad. ♀s, a few ad. ♂s, and some young; June, an ad. ♂, and several ♀s both ad. and imm.; July, imm. and young ♀s; Aug., two ad. and several imm. ♂s and many ♀s, a few only being ad.; Sept., a few imm. ♂s and many ♀s, a few being ad. and some quite young; Oct., numerous imm. and young examples, and a few ad. ♀s; Nov., numbers young and imm.; Dec., ad. ♂ and a few ♀s, one being mature.

Xysticus bifasciatus (C. L. K.).

Thomisus bifasciatus, Bl. Spid. Great Brit. and Irel.

Found on Arthur's Seat, in June 1861, by Mr Cambridge We have not as yet taken it ourselves in the district Kincraig, in Inverness-shire, being indeed the only Scottish locality in which we have detected it.

Xysticus erraticus (Bl.).

Thomisus erraticus, Bl. Spid. Great Brit. and Irel.

This species was also found by Mr Cambridge on Arthur's Seat in June 1861. It has been taken at Banchory, in Kincardineshire, by Professor Trail, but like the last it is evidently a rare spider in Scotland.

Oxyptila trux (Bl.).

Thomisus trux, Bl. Spid. Great Brit. and Irel.

Apparently not common, but females and immature examples may have occasionally been mistaken for those of the next species. Males adult in autumn.

Otterston (Fife), April, two ♀s, one ad. the other young; Arthur's Seat, April, imm. ♀ (taken by O. P. C. in this locality in June 1861); Kirknewton and Blackford Hill, May, two ad. ♀s; heath near West Wemyss Station, Sept., ad. ♂ and two ♀s; at roots of grass by side of ditch, Kilconquhar, Sept., four ad. ♂s and several imm. ♂s and ♀s; Keilsden, Largo, Sept., ad. ♂ and ♀; Luffness Links, ad. ♂ Sept., ad. ♀ and others imm. Oct.; field opposite Morton Hall west gate, Jan., ad. ♂.

Oxyptila atomaria (Panz.).

Thomisus versatus + *T. pallidus*, Bl. Spid. Great Brit. and Irel.

Appears to be widely distributed and fairly common. We have not yet met with the adult male here, but judging by Mr Cambridge's experience in Dorset, and our own in Inverness-shire, we may suppose it occurs in May and June.

Roadside, Hillend, Feb., ad. ♀ and two young; Arthur's Seat and Salisbury Crags, March, eight or nine ad. ♀s and as many imm. (Mr Cambridge found it in this locality and on the Pentlands in June 1861); Loganlee (Pentlands), March, five ♀s nearly but not quite ad.; Aberdour, April, two ♀s (one ad.); in wood near Aberdour, among dead leaves, one ad. and two young ♀s of the very pale variety—the *T. pallidus*, Bl.; Arthur's Seat, Aug., ad. ♀; Luffness, Sept., two imm. ♀s; Do., Oct., ♂ and ♀ imm. (O. P. C.); Boghall (south side of Pentlands), Oct., ♂s and ♀s imm.; Bonaly Glen, Oct., young ♀; roadside, Kaimes, Dec., numerous ♀s imm.

Oxyptila simplex, Cb.

An adult female *Oxyptila*, found on 13th June 1894, beside a stone in an old limestone quarry at Longniddry, East Lothian, has been identified by Mr Cambridge as belonging to this species, which has not hitherto been recorded for Scotland.

Philodromus aureolus (Cl.).

Generally distributed and abundant; easily obtained by beating furze and other low bushes. Adult about the beginning of summer.

Botanic Garden, March, several imm.; Corstorphine Hill, Hopetoun, Aberdour, etc., April, many imm. ♂s and ♀s, some quite small; Braid Hills, Belstane near Kirknewton, etc., May and June, many ♂s and ♀s ad. and imm.; Seafield, end of June, a few quite small; Dreghorn, Penicuik, July, several imm., others young; Rosslyn, July, ad. ♀ beside her brood; Arthur's Seat, Aug., a few young; Thornton, Leven, etc.; Aug., a few ad. ♀s and numbers imm. and young; Glencorse, Aberlady, Gullane, Tyninghame, Sept., several ad. ♀s and many imm.; Bridge of Allan, Dec., ♂ and ♀ imm.

Family LYCOSIDÆ.

Pirata piraticus (Cl.).

Lycosa piratica, Bl. Spid. Great Brit. and Irel.

Widely distributed and common in marshy ground. The majority breed about June, but we have seen a female carrying her egg-cocoon in September.

Balerno, Glencorse Reservoir, etc., March, a number imm.; Bavelaw Moss, Aberdour, Burntisland, Otterston, April, many imm., some quite small; Luffness Marshes, May, ad. ♀, and numerous imm. ♂s and ♀s; Duddingston Loch, Luffness Links, etc., June, ad. ♂s and ♀s common, a number of the latter carrying egg-cocoons; Peebles, July, a few ad. ♀s; Moss near Thornton, Aug., common, ad. and imm.; Drumshoreland Curling-Pond, Leven, Luffness, Sept., common, ad. and imm., a few ♂s ad.; Kilconquhar, Sept., ♀ carrying egg-cocoon; Luffness, Oct., young common.

Trochosa picta (Hahn).

Lycosa picta, Bl. Spid. Great Brit. and Irel.

This handsome and most interesting spider is common on sandhills on both sides of the Firth of Forth, where it may be seen running in the sunshine, or may be dug from its tubular hole in the sand. Adult males in spring and summer.

Pettycur Links, Fife, 24th March, common, ad. ♂s and ♀s, and imm. examples of various sizes; bay to west of Aberdour, April, ad. ♂s and ♀s in their cells; shore at Dalmeny Park, April, ad. ♂ and ♀; sandhills, Luffness and Gullane Links, ad. ♂s and ♀s and imm. examples of various sizes, common, running or basking in the sunshine; Do., Aug., Sept., and Oct., many ad. ♀s in their cylindrical cells; coast between Leven and Elie, Aug., a few ad. ♀s in their cells, and young common on the sand.

Trochosa ruricola (De G.).

Lycosa campestris, Bl. Spid. Great Brit. and Irel.

Not common, and apparently very much confined to the coast-line.

Dalgetty Bay, under stones at high-water mark, April, two ♂s and two ♀s ad.; Dalmeny Park, April, ad. ♀; Gorebridge, April, ad. ♀; Aberlady, at foot of wall, May, ad. ♂ and three ♀s; Leven Links, Aug., ad. ♀; Luffness Links, Sept., two ♂s and six ♀s ad.; Tyninghame Bay, under stones, Sept., numerous ♂s and ♀s; Luffness, Oct., two ad. ♀s and several young.

Trochosa terricola, Thor.

Lycosa agretyca, Bl. Spid. Great Brit. and Irel.

Widely distributed and not uncommon.

Foot of Carnethy (Pentlands), under stone, 24th March, ad. ♂ and ♀; Aberdour and Dalmeny, April, two ad. ♀s; Braid Hills, 25th April, ♀ with egg-cocoon; Pentlands, above Hillend, May, very large ♀; Pettycur, June, imm. ♀; Arthur's Seat, Aug., ad. ♂; Leven, Aug., ad. ♀; Luffness, Sept., ♂; Balerno, Sept., two imm. ♀s; Glencorse, Sept., ♀; Pentlands above Boghall, Oct., several young ♀s.

Trochosa pulverulenta (Cl.).

Lycosa rapax, Bl. Spid. Great Brit. and Irel.
Tarentula pulverulenta, Cambr. Spid. Dorset.

Widely distributed and common. The majority attain maturity in May, but the time varies a little, of course, according to the nature of the season.

Moor above Currie and near Cobbinshaw, second half of March, a number of imm. ♂s and ♀s; on south side of Carnethy, 24th March, ♂s and ♀s in great abundance, but apparently all still imm.; Donibristle, etc., April, a good many, some ad.; Dalmeny Park, wood near Kirknewton, etc., May, ad. ♂s and ♀s common; moor near Thornton, Aug. and Sept., a few ad. ♀s and many imm.; Glencorse and Balerno, Sept., a few imm.; Pentlands above Boghall and near Bavelaw Castle, a good many imm. and young.

Trochosa andrenivora (Cl.).

Lycosa andrenivora, Bl. Spid. Great Brit. and Irel.

This fine species—one of the finest of a fine genus—is rare in the district, the only localities in which we have as yet found it being on the coast of Fife.

Pettycur Links, among roots of grass on overhanging sandhill, 24th March 1893, ad. ♂ and two ♀s and four young; Leven Links, 12th Aug., two imm. ♀s.

Lycosa amentata (Cl.).

Lycosa saccata, Bl. Spid. Great Brit. and Irel.

Generally distributed and very common. Towards the end of April and during May the majority attain maturity, and females carrying their egg-cocoons are common in May and June. Three cocoons examined contained 33, 41, and 56 eggs respectively.

The following is an analysis of our records, leaving out localities:—Feb., a number young and imm.; March, many imm. ♂s and ♀s and young; April, many imm. ♂s and ♀s and some ad.; May, many ad. ♂s and ♀s; June, numerous ad. ♂s and ♀s, many of the latter carrying egg-cocoons—also one or two imm. ♀s; July, numbers of ♀s ad. and imm., a few with egg-cocoons; Aug. and Sept., a few ad. ♀s and many imm. (mostly ♀s) and young; Oct., a few imm.

Lycosa lugubris, Walck.

Apparently very local, but common where it does occur.

Wood about a mile north-east of Aberdour, among withered leaves, 10th April 1893, ad. ♂s and ♀s abundant; Durie House, near Leven, among withered beech leaves, Aug. and Sept., many imm. ♂s and ♀s.

Lycosa pullata (Clk.).

Lycosa obscura, Bl. Spid. Great Brit. and Irel.

Universally distributed and very common. During April, May, and June adults of both sexes are abundant. The at Dunkeld, and at Muchalls, near Aberdeen, by Professor Trail.

Aberdour, among stones on sunny bank on east side of the harbour, 6th and 9th April 1893, ♂ and several ♀s well grown but still imm.

Neon reticulatus (Bl.).

Salticus reticulatus, Bl. Spid. Great Brit. and Irel.

Extremely local, indeed we know of only one habitat in the district, namely, the Queen's Park, Edinburgh, where it was discovered by Mr Cambridge in June 1861, and where it is still fairly common. In the north and west of Scotland we have taken it at Aviemore and at Oban.

Under stones at foot of Salisbury Crags, Queen's Park, March and April, common, ad. ♀s and imm. ♂s and ♀s; Do., June, ad. ♂s and ♀s.

Euophrys erraticus (Walck.).

Salticus distinctus, Bl. Spid. Great Brit. and Irel.

This appears to be also a very local species in the district. It has been taken near Paisley by Mr Morris Young, and we have found it at Aviemore in Inverness-shire.

Blackford Hill, among stones, March and April, common, some ad.; again, May, ad. ♂s and ♀s and some quite small; again, Dec., ♂s and ♀s (some of the latter ad.) hibernating; Arthur's Seat, above Duddingston, March and April, a number of ad. ♀s and imm. ♂s and ♀s.

as often on a dry bank or hillside as in any other kind of locality.

Dalmeny Park, under log, Jan., two young ♀s; Arthur's Seat, Pettycur, Carnethy, Leadburn, March, a good many imm. ♂s and ♀s; Donibristle, April, a few imm. ♂s and ♀s; Pentlands, Luffness Links, May, a few ad. ♂s and ♀s; Pettycur, Luffness Links, June, a number of ad. ♂s and ♀s (some carrying egg-cocoons); Thornton and Leven Links, Aug., four ad. ♂s and several ♀s (some carrying eggs), imm. and young common; Keilsden (Largo), Luffness, Sept., a few ad. ♀s, others young; near Bavelaw Castle, Turnhouse Hill, Luffness, Oct., a few imm. ♂s and ♀s; Bridge of Allan, Dec., ♂ and ♀ half grown, and one quite small.

Lycosa monticola (C. L. K.).

Lycosa exigua (in part), Bl. Spid. Great Brit. and Irel.

Apparently very local, and probably pretty much confined to the vicinity of the sea.

Leven Links (Fife), 10th Aug. 1893, an ad. ♀; Isle of May, 16th Aug., three ad. ♀s and several imm. Mr Cambridge has seen some of these specimens, and confirms our identification.

Family **ATTIDÆ.**

Epiblemum scenicum (Cl.).

Salticus scenicus (in part), Bl. Spid. Great Brit. and Irel.

Widely distributed and common. On bright sunny days from spring to autumn it may be seen hunting for flies on the warm surface of walls, rocks, and occasionally palings, and in the crevices of these it passes the winter in a silken cell.

North Morton, Feb., common (ad. ♀s and imm. ♂s and ♀s), hibernating under loose lime on wall; Arthur's Seat, Craiglockhart Hill, Pettycur, March, numerous ad. ♀s and imm. ♂s and ♀s; wall at Comiston, April, ♀; Aberlady, Tynefield, etc., May, ad. ♂s and ♀s; Morningside Park (on wall), Braid Hills (on rocks), etc., June and July, many ad. ♂s and ♀s (especially the latter), and some young; Merchiston, Lundin Tower (Leven), Aberlady, Tyninghame (on paling), Aug. and Sept., a number of ♂s, more ♀s.

Heliophanus cupreus (Walck.).

Salticus cupreus, Bl. Spid. Great Brit. and Irel.

Rare, and probably very much confined to rough banks on or near the shores of the Firth of Forth. Has been taken

The female resembles the male in the general character of its markings, but the abdomen is of a whiter ground colour.

This spider is nearly allied to *Dictyna borealis*, Cambr., described from North Greenland,[1] but differs in having the legs destitute of dark annulations (the legs of the male being wholly immaculate, and in one only out of a dozen females was a very faint trace of annulation visible), and in the broad sub-abdominal black band, which is absent in the Greenland spider. From *Dictyna arundinacea*, Linn., the longer radial joint of the palpus and the longer spur (springing from its very extremity) distinguishes it at once, while from *Dictyna uncinata*, Thor., not only does the spur, being shorter than in that species, distinguish it, but the abdominal pattern and markings are totally different. It is also allied to *Dictyna pusilla*, Westr., but the latter is a smaller and darker spider, and differs likewise in the structure of its palpi. The habits of this spider are quite unusual—the males appearing to frequent bare sandy spots on the sea-shore, while the females conceal themselves under fragments of sea-weed, blown beyond high water-mark, and in these form their slight snares and egg-cocoons.

Adults of both sexes were found by Mr William Evans close to the shore on Luffness Links, East Lothian, in June 1894. A number of immature examples had been taken by him in the same locality during the previous autumn.

EXPLANATION OF PLATE XII.

Dictyna arenicola, sp. n.

Fig. 1. Spider (♂), magnified.
Fig. 2. Profile of cephalothorax and palpus of ♂.
a. Radial joint of palpus, showing characteristic spur.

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[1] Ann. and Mag. Nat. Hist, ser. 4, vol. xx., p. 273, pl. viii., fig. 1 (1877).

JOURNAL OF PROCEEDINGS.

SESSION CXXII.

Wednesday, 16*th November* 1892.—JOHNSON SYMINGTON, Esq., M.D., F.R.S.E., retiring Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Albert A. Lintern, Esq., B.Sc.

The retiring Vice-President delivered an Opening Address on "The Cerebral Convolutions in the Primates."

Dr Traquair, F.R.S., exhibited an unusually coloured specimen of the Thornback (*Raia clavata*).

Wednesday, 21*st December* 1892.—Professor H. ALLEYNE NICHOLSON, F.G.S., F.L.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Thomas Bowhill, Esq., F.R.C.V.S.; Henry Mainwaring-Holt, Esq., M.R.C.S., L.S.A.; Edward Laidlaw Thomson, Esq.

The Acting-Secretary submitted the following Report by the Council:

REPORT OF COUNCIL, 1891-92.

The Council beg to submit the following Report upon the state of the Society.

I.—MEMBERSHIP.

During the past Session the number of new Fellows admitted amounted to twelve, but against these must be placed the names of Fellows deceased, resigned, or written off the roll as being four years or over in arrear with their subscriptions. These amounted to twenty-five, leaving at the end of the Session,

	225	Ordinary Fellows,
	16	Honorary Fellows,
	19	Corresponding Fellows,
Total	260	Fellows.

II.—ACCOUNTS.

An Abstract of the Treasurer's Accounts has been circulated with the Billet calling this meeting. It will be seen therefrom that the funds continue in a satisfactory condition.

III.—THE SECRETARY.

The Council deeply regret to announce that they have temporarily lost the valued services of the Secretary. The state of Mr Evans's health being such as to necessitate his absence abroad for a period, he tendered his resignation as Secretary. The Council, however, resolved not to accept this resignation, but granted Mr Evans leave of absence for a year, and appointed Mr Gunn as Acting-Secretary during that time. Mr Evans acquiesced in this decision.

IV.—COMMUNICATIONS.

The number of Communications read before the Society during last Session was nineteen, of which thirteen are to appear in the forthcoming part of the *Proceedings*, which, it is hoped, will be in the hands of Fellows before next ordinary meeting. This part is to be illustrated by eight plates.

V.—CONCLUSION.

In conclusion, the Council would impress upon Members the necessity of introducing as Fellows of the Society, gentlemen who are in any way likely to promote its interests, especially by the contribution of papers calculated to add to the value and interest of the Society's *Proceedings*.

For the Council,

JOHN GUNN, *Acting-Secretary.*

Thereafter, the Treasurer submitted his Annual Report.

The following Office-Bearers for the Session were then elected :

President.—Professor H. ALLEYNE NICHOLSON, F.G.S., F.L.S.

Vice-Presidents.—ROBERT KIDSTON, F.G.S., F.R.S.E. ; B. N. PEACH, F.R.S., F.G.S. ; WILLIAM RUSSELL, M.D., F.R.C.P.E.

Secretary.—WILLIAM EVANS, F.F.A., F.R.S.E.

Acting-Secretary.—JOHN GUNN, F.R.S.G.S.

Treasurer.—GEORGE LISLE, F.F.A., C.A.

Councillors.—J. G. Goodchild, F.G.S., F.Z.S. ; Professor J. Berry Haycraft, M.D., F.R.S.E. ; Lionel W. Hinxman, H.M. Geological Survey ; Thomas Scott, F.L.S. ; James Bennie, H.M. Geological Survey ; George Brook, F.L.S., F.R.S.E. ; R. W. Felkin, M.D., F.R.S.E. ; R. H. Traquair, M.D., F.R.S. ; Edmond W. Carlier, M.D., B.Sc. ; Major Wardlaw Ramsay ; Johnson Symington, M.D., F.R.S.E. ; Andrew Wilson, L.D.S.

The following communications were read :

1. "The Glacial Fauna of King Edward, Banffshire." By ALFRED BELL, Esq. (Communicated by JAMES BENNIE, Esq.)
2. "Further Observations upon the Wings of Birds." By J. G. GOODCHILD, Esq., F.G.S., F.Z.S.
3. In connection with the above, Mr GOODCHILD exhibited a Collection of the Wings of Birds.

Wednesday, 18th January 1893.—ROBERT KIDSTON, Esq., F.G.S., F.R.S.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: James Adamson, Esq., M.A., B.Sc.; Kenneth Findlater Campbell, Esq., C.E., Hon.M.Inst.C.E., M.S.I.; T. Lewis Paterson, Esq., M.B., C.M.

The Librarian submitted his Annual Report.

The following communications were read:

1. "The Chemistry of Soils." By JOHN HUNTER, Esq., F.C.S.
2. "A Revised Description of *Palæospondylus Gunni.*" By R. H. TRAQUAIR, Esq., M.D., F.R.S.
3. "Results of Meteorological Observations taken at Edinburgh in 1892." By R. C. MOSSMAN, Esq., F.R.Met.S., F.R.S.E.

Wednesday, 15th February 1893.—Professor H. ALLEYNE NICHOLSON, F.G.S., F.L.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Professor Cargill G. Knott, D.Sc., F.R.S.E.; Gustav Mann, Esq., M.B., C.M.; William Reid Tait, Esq., C.E.

The following communications were read:

1. "Heredity and its Bearings on the Phenomena of Atavism." By GUSTAV MANN, Esq., M.B., C.M.
2. "On the Identity of *Rubecola Tytleri*, Jameson (*Mem. Wern. Soc.*, vii., p. 487), with Exhibition of Specimen." By W. EAGLE CLARKE, Esq., F.L.S.
3. "Lists of Foraminifera and Ostracoda from the Raised Sea-Bottom at Fillyside." By DAVID ROBERTSON, Esq., F.L.S. (Communicated by JAMES BENNIE, Esq.)
4. "Exhibition of Professor BÜTSCHLI'S Micro-Photographs." By J. ARTHUR THOMSON, Esq., M.A., F.R.S.E.

Wednesday, 15th March 1893.—B. N. PEACH, Esq., F.G.S., F.R.S. Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Lieut.-Colonel Fred. Bailey, (*late*) R.E., F.R.G.S.; Percy H. Grimshaw, Esq.; Alexander Macdonald, Esq., M.B., C.M.

The following communications were read:

1. "Some of the Practical Benefits resulting from Bacteriological Research." By WILLIAM RUSSELL, Esq., M.D., F.R.C.P.E.
2. "Remarks on the Fossil Fishes of the Devonian Rocks of Canada." Part I. By R. H. TRAQUAIR, Esq., M.D., F.R.S.
3. "On the Occurrence of *Arthostigma gracile*, Dawson, in the Lower Old Red Sandstone of Perthshire." By ROBERT KIDSTON, Esq., F.G.S.,

4. "Remarks on *Scorpæna dactyloptera*, Delaroche; an addition to the Fauna of the British North Sea Area." By W. Eagle Clarke, Esq., F.L.S.
5. "On some New or Little Known Oligochæta." By F. E. Beddard, Esq., M.A., F.R.S.

Wednesday, 19*th April* 1893.—Robert Kidston, Esq., F.G.S., F.R.S.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: O. C. Bradley, Esq., M.R.C.V.S.; E. F. de Jong, Esq., M.R.C.V.S.; Charles Campbell Baxter Tyrie, Esq., M.B., C.M.; Edward John Wynstone Waters, Esq.

The following communications were read:

1. "Remarks on the Fossil Fishes of the Devonian Rocks of Canada." Part II. By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
2. "A List of Spiders collected in the Neighbourhood of Edinburgh." By William Evans, Esq., F.R.S.E., and G. H. Carpenter, Esq.
3. "The Ancient Lake of Elie, Fifeshire." By James Bennie, Esq., and Andrew Scott, Esq.
4. "The Land and Fresh-Water Crustacea of the District around Edinburgh. Part II.—The Ostracoda and Copepoda." By Thomas Scott, Esq., F.L.S.
5. "Exhibition of a Specimen of the Ivory Gull (*Pagophila eburnea*)." By W. Eagle Clarke, Esq., F.L.S.

SESSION CXXIII.

Wednesday, [illegible] *November* 1893.—Robert Kidston, Esq., F.G.S., F.R.S.E., retiring Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: James A[illegible] Terras, Esq., B.Sc.

The following gentleman was elected an Honorary Fellow of the Society: Professor Charles Lapworth, F.R.S.

The retiring Vice-President delivered an Opening Address, "On the Various Divisions of British Carboniferous Rocks as determined by their Fossil Flora."

Professor Struthers and Professor Cossar Ewart exhibited, with Remarks, Specimens showing the Development of the Foot of the Horse, as bearing on the Evolution of the Species.

Wednesday, 20*th December* 1893.—B. N. Peach, Esq., F.G.S., F.R.S., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: John Alexander, Esq., M.D., L.R.C.P., L.R.C.S., D.P.H.; George Ernest Clemons, Esq., M.B., C.M.; Charles W. Donald, Esq., M.B., C.M.; H. B.

Guppy, Esq., M.B., F.R.S.E.; D. C. Longden, Esq., M.B., M.R.C.S.Eng., D.P.H., F.R.C.S.E.; Alexander Mackay, Esq., Solicitor; Thomas Wright Parkinson, Esq., M.B., C.M.; Matthew Scott, Esq., C.E.

The Acting-Secretary read the following Report by the Council:

REPORT BY COUNCIL, 1892-93.

I—Membership.

During the past Session the number of Ordinary Fellows admitted amounted to seventeen, against which have to be placed seven resignations and three deaths, leaving a nett increase of seven names upon the roll. The name of a Life Member whose name had been inadvertently allowed to lapse from the roll has been restored. At the close of the Session the number of Fellows was,

233 Ordinary Fellows,
16 Honorary Fellows,
19 Corresponding Fellows,

Total 268 Fellows.

II.—Accounts.

An Abstract of the Treasurer's Accounts, in printed form, has been distributed with the Billet calling this meeting. It will be seen therefrom that the funds continue in a fairly satisfactory condition, although the amount of arrears is considerable.

III.—Communications.

The number of Communications read before the Society during the past Session was twenty, of which sixteen appeared in the part of the *Proceedings* already issued to Fellows not in arrear. This part was illustrated by three plates and eight woodcuts. Besides the papers read, objects of scientific interest were exhibited on four occasions.

With a view to the future early publication of the *Proceedings*, the Council request Fellows to hand in their Communications, with the Illustrations, if any, complete, at the conclusion of the meeting at which they are read, in order that they may receive early consideration.

IV.—The Secretary.

The Council deeply regret to announce that they have lost the valued services of the Secretary, the state of whose health continues such as to disable him, for the present, from carrying on the duties he so successfully and unweariedly performed for the Society. The Council have adopted the following Minute, a copy of which has been forwarded to Mr Evans:—

"It is with feelings of great regret that the Council have received the resignation of Mr William Evans as Secretary of the Society, on account of ill health. Combining, as he does, all the qualities desirable in an efficient Secretary, Mr Evans has, during the five years he has held the post, served the Society well, and has amply earned the admiration, as well as the gratitude, of its Members. Taking up office at a time when the Society was just emerging from a period of financial depression, his wisdom and capacity in guiding its affairs has been rewarded by the position of prosperity which the Society at present enjoys, while his solid reputation as a naturalist has greatly contributed towards raising and maintaining its position as a scientific body.

"The Council especially deplore the cause of Mr Evans's resignation, and earnestly hope that he may be speedily restored to health, so that not only the Royal Physical Society, but natural history science in general, may soon again enjoy the benefit of his work."

V.—Conclusion.

In conclusion, the Council would impress upon Members the necessity for introducing as Fellows of the Society, gentlemen who are likely to promote its interests in any way, especially by the contribution of papers calculated to add to the value and interest of the Society's *Proceedings*.

For the Council,

John Gunn, *Acting-Secretary*.

The Treasurer and Librarian submitted their Annual Reports.

The following Office-Bearers were elected:

President.—Professor H. Alleyne Nicholson, F.G.S., F.L.S.

Vice-Presidents.—B. N. Peach, Esq., F.G.S., F.R.S.; William Russell, Esq., M.D., F.R.C.P.E.; J. G. Goodchild, Esq., F.G.S., F.Z.S.

Secretary.—John Gunn, F.R.S.G.S.

Assistant-Secretary.—J. Stuart Thomson.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] of the Caithness Flags. By R. H. Traquair, Esq., M.D., LL.D., F.R.S.

[illegible] By R. H. Traquair, Esq., M.D., LL.D., F.R.S.

[illegible] New [illegible] Fossil Plants from the Lower Carboniferous Rocks [illegible] By R. [illegible] Kidston, Esq., F.G.S., F.R.S.E.

[illegible] *Proceedings* [illegible]

Wednesday, 17th January 1894.—Professor H. Alleyne Nicholson, F.G.S., F.L.S., President, in the Chair,

The following gentlemen were elected Ordinary Fellows of the Society: J. H. Burrage, Esq., B.A. (Oxon.); James Bell Dobbie, Esq.; William Taylor, Esq.

A letter from Mr Evans was submitted, in which he thanked the Council for the Minute prepared by them on his resignation.

The following communications were read:

1. "Obituary Notice of the late George Brook, F.L.S., F.R.S.E." By W. E. Hoyle, Esq., F.R.S.E.
2. "Obituary Notice of the late Charles Jenner, F.G.S., F.R.S.E." By J. G. Goodchild, Esq., F.G.S., F.Z.S.
3. "On some Entomostraca from the Island of Mull, collected by the late Mr George Brook." By Thomas Scott, Esq., F.L.S.
4. "River Temperature. Part I. Its Daily Changes and Methods of Observation." By H. B. Guppy, Esq., M.B., F.R.S.E.
5. "Animal Life observed during a Voyage to Antarctic Seas." By W. S. Bruce, Esq. (Communicated by the Secretary.)

Wednesday, 21st February 1894.—J. G. Goodchild, Esq., F.G.S., F.Z.S., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: T. Cuthbert Day, Esq., F.C.S.; D. R. Simpson, Esq.

The following communications were read:

1. "An Attempt to explain the Origin of Certain Organs." By J. Arthur Thomson, Esq., M.A., F.R.S.E.
2. "Meteorological Observations taken in Edinburgh in 1893." By R. C. Mossman, Esq., F.R.Met.S., F.R.S.E.
3. "Penguins: with Notes on those of Erebus and Terror Gulf." By C. W. Donald, Esq., M.B., C.M.
4. "Exhibition, with Remarks, of Transverse Sections of Carboniferous Wood from Baberton New Quarry, Midlothian." By James Bennie, Esq., and J. A. Johnston, Esq.

Wednesday, 21st March 1894.—William Russell, Esq., M.D., F.R.C.P.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: William Speirs Bruce, Esq.; Edward Greenly, Esq., F.G.S.; W. Denison Roebuck, Esq., F.L.S.

The following communications were read:

1. "Obituary Notice of the late Rev. G. Gordon, LL.D." By J. Horne, Esq., F.G.S.

2. "The Reptiles and Batrachians of the Edinburgh District." By William Evans, Esq., F.R.S.E.
3. "Remarks on the Tectibranchiata: with Demonstration of Specimens." By J. D. F. Gilchrist, Esq., Ph.D., B.Sc.
4. "Notes on some Carboniferous Lamellibranchs." Part III. By J. G. Goodchild, Esq., F.G.S., F.Z.S.

Wednesday, 18th April 1894.—J. G. Goodchild, Esq., F.G.S., F.Z.S., Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: William Paterson Scott, Esq., C.A.

Messrs R. C. Millar, C.A., and Richard Brown, C.A., were re-appointed Auditors for the current Session.

The following communications were read:

1. "On the Distribution of Tropical Diseases in Africa." By R. W. Felkin, Esq., M.D., F.R.S.E.
2. "The Land and Fresh-Water Crustacea of the District around Edinburgh. Part III.—The Cladocera." By Thomas Scott, Esq., F.L.S.
3. "A Contribution to the Vertebrate Fauna of West Ross-shire." By Lionel Hinxman, Esq., B.A., and W. Eagle Clarke, Esq., F.L.S.
4. "Notes on some of the Southern Whales." By Charles W. Donald, Esq., M.B., C.M.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS."

Those Institutions from which Publications have been received in return are indicated by an asterisk.

ENGLAND.

Birmingham,	*Philosophical Society, King Edward's Grammar School.
Do.	*Natural History Society, Sir Josiah Mason's College.
Cambridge,	*Philosophical Society.
Do.	University Library.
Cirencester,	*Editor of the *Agricultural Students' Gazette.*
Durham,	University Library.
Halifax,	*Yorkshire Geological and Polytechnic Society.
Leeds,	*The Conchological Society of Great Britain and Ireland.
Liverpool,	*Biological Society, University College.
Do.	*Literary and Philosophical Society.
Do.	*Engineering Society, Royal Institution.
London,	British Museum Library.
Do.	*British (Natural History) Museum, South Kensington.
Do.	*Royal Society, Burlington House, Piccadilly, W.
Do.	Chemical Society, Burlington House, Piccadilly, W.
Do.	*Geological Society, Burlington House, Piccadilly, W.
Do.	*Linnean Society, Burlington House, Piccadilly, W.
Do.	*Royal Microscopical Society, King's College.
Do.	Museum of Economic Geology, Jermyn Street.
Do.	Editor of *Nature*, 29 Bedford Street, Covent Garden.
Do.	*Zoological Society, Hanover Square.
Do.	*Geologists' Association, University College, W.C.
Manchester,	*Geological Society, 36 George Street.
Do.	*Literary and Philosophical Society, 36 George Street.
Do.	*The Owens College.
Norwich,	*Norfolk and Norwich Naturalists' Society, The Museum.
Oxford,	Bodleian Library.
Truro,	*Royal Institution of Cornwall.
Watford,	*Hertfordshire Natural History Society and Field Club.

SCOTLAND.

Aberdeen,	University Library.
Cockburnspath,	*Berwickshire Naturalists' Field Club, Old Cambus.
Edinburgh,	Advocates' Library.
Do.	University Library.
Do.	*Royal Society.
Do.	Royal Medical Society.

EDINBURGH,	*Royal Scottish Society of Arts.
Do.	*Royal Scottish Geographical Society.
Do.	*Botanical Society.
Do.	*Highland and Agricultural Society.
Do.	*Geological Society.
GLASGOW,	*Philosophical Society.
Do.	*Natural History Society.
Do.	*Geological Society.
Do.	*Andersonian Society.
Do.	University Library.
PERTH,	Perthshire Society of Natural History.
ST ANDREWS,	University Library.

IRELAND.

BELFAST,	Natural History and Philosophical Society
DUBLIN,	*Royal Irish Academy.
Do.	*Royal Dublin Society.
Do.	*Royal Geological Society of Ireland.

HOLLAND.

AMSTERDAM,	*De Koninklijke Akademie van Wetenscnappen.
LEYDEN,	*Museum van Naturlijke Histoire.
UTRECHT,	Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

BASLE,	*Die Naturforschende Gesellschaft.
BERN,	*Allgemeine Schweizerische Gesellschaft für die gesammten Naturwissenschaften.
Do.	*Die Naturforschende Gesellschaft.
GENEVA,	Société de Physique et d'Histoire Naturelle.
NEUCHATEL,	Société des Sciences Naturelles.
ZÜRICH,	Die Naturforschende Gesellschaft.

GERMANY.

BERLIN,	Konigliche Akademie der Wissenschaften.
Do.	*Deutsche Geologische Gesellschaft.
Do.	*Gesellschaft Naturforschender Freunde.
BONN,	*Naturhistorischer Verein der preussischen Rheinlande Westfalens, und des Reg.-Bezirks Osnabruck.
BREMEN,	Verein fur Naturwissenschaft.
BRESLAU,	*Schlesische Gesellschaft fur Vaterlandische Cultur.
BRUNSWICK,	*Naturwissenschaftlicher Verein.
DRESDEN,	Konigliche Sammlungen fur Kunst und Wissenschaft.
Do.	*Der Verein fur Erdkunde.
ELBERFELD,	*Naturwissenschaftlicher Verein.
ERLANGEN,	University Library.
FRANKFORD-ON-MAIN,	*Senckenbergische Naturforschende Gesellschaft.
Do.	*Deutsche Malakozoologische Gesellschaft, Dr Kobelt, Schwanheim.
FREIBURG, i. B.,	Die Naturforschende Gesellschaft.
GOTTINGEN,	*Konigliche Gesellschaft der Wissenschaften.
HALLE,	*Kaiserliche Akademie der Naturforscher.

JENA,	*Medicinisch-naturwissenschaftliche Gesellschaft.
LEIPZIG,	*Königliche Sächsische Gesellschaft der Wissenschaften.
Do.	Naturforschende Gesellschaft.
Do.	Editor of the *Zoologischer Anzeiger*.
MUNICH,	*Königliche Baierische Akademie der Wissenschaften.
STUTTGART,	*Verein für Vaterländische Cultur in Württemberg.
WÜRZBURG,	*Physikalisch-medicinische Gesellschaft.

AUSTRIA.

AGRAM,	*Societas Croatica Historico-naturalis.
HERMANNSTADT,	*Siebenbürgischer Verein für Naturwissenschaft.
PRAGUE,	Königliche-böhmische Gesellschaft der Wissenschaften.
TRIESTE,	Società Adriatica di Scienze Naturali.
VIENNA,	*K. k. zoologisch-botanische Gesellschaft.
Do.	*K.k. Naturhistorisches Hof-Museum.

ITALY.

BOLOGNA,	*Accademia delle Scienze dell' Istituto.
MILAN,	*Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do.	Società Italiana di Scienze Naturali.
MODENA,	Società dei Naturalisti.
NAPLES,	Editor of the *Zoologischer Jahresbericht*, Zoological Station.
PADUA,	*Società Veneto-Trentina di Scienze Naturali residente in Padova.
ROME,	*Reale Accademia dei Lincei.
TURIN,	*Reale Accademia delle Scienze.

SPAIN.

MADRID,	*Real Academia de Ciencias exactas, fisicas e naturales.
Do.	Sociedad española de Historia natural.

PORTUGAL.

COIMBRA,	Bibliothèque de l'Université.
LISBON,	*Academia Real das Sciencias.

FRANCE.

BORDEAUX,	La Société Linnéenne.
CAEN,	Société Linnéenne de Normandie.
CHERBOURG,	*Société Nationale des Sciences Naturelles.
PARIS,	*Académie des Sciences de l'Institut.
Do.	*Société Géologique de France, Rue des grands Augustins, 7.
Do.	*Société Zoologique de France, Rue des grands Augustins, 7.
Do.	Société de Biologie.
Do.	École des Mines.

BELGIUM.

BRUSSELS,	*Académie Royale des Sciences, des Lettres, et des beaux Arts.
Do.	*Société Royale Malacologique de Belgique.
Do.	*Société Belge de Microscopie.

SCANDINAVIA.

Bergen, ...	*The Museum.
Christiania, ...	*Videnskabs-Selskabet.
Do. ...	Universitets-Bibliotheket.
Copenhagen, ...	*Kongelige Danske Videnskabernes Selskab.
Do. ...	*Naturhistoriske Forening.
Stockholm, ...	*Kongliga Svenska Vetenskaps-Akademien.
Upsala, ...	*Kongliga Vetenskaps-Societeten.
Do.	*Universitets Bibliotheket.

RUSSIA.

Dorpat, ...	*Naturforscher Gesellschaft.
Kiev, ...	*Natural History Society.
Moscow, ...	*Société Impériale des Naturalistes.
St Petersburg, ...	*Académie Impériale des Sciences.
Do. ...	*Imperial Botanic Garden.

AMERICA.

United States.

Albany, N.Y., ...	*New York State Library.
Baltimore, ...	*Johns Hopkins University Library.
Boston, ...	*American Academy of Arts and Sciences.
Do.	*Society of Natural History.
Brookville, Ind.,	*Brookville Society of Natural History.
Cambridge, Mass.,	*Harvard University Library.
Do.	*Museum of Comparative Zoology.
Chicago, ...	*Academy of Sciences.
Cincinnati, ...	*Society of Natural History.
New Haven, Conn.,	*Connecticut Academy of Arts and Sciences.
[illegible]	[illegible]

[illegible]

Do.	*[illegible] Observatory.
Do.	*[illegible] Observatorio Meteorológico Central.

Canada.

Hamilton,	*The Hamilton Association.
Kingston,	*Queen's University.

MANITOBA, . .	*Historical and Scientific Society, Winnipeg.
MONTREAL, . .	*The Natural History Society.
OTTAWA, . .	*Canadian Geological Survey.
Do. . .	*Royal Society of Canada.
TORONTO, . .	*The Canadian Institute.

NOVA SCOTIA.

HALIFAX, . .	*Nova Scotia Institute of Natural Science.

BRAZIL.

RIO DE JANEIRO, .	Museu Nacional.

AFRICA.

CAPE TOWN, . .	South African Philosophical Society.

ASIA.

BATAVIA, . .	*Koninklijke Natuurkundige Vereeniging in Nederlandsch Indie.
CALCUTTA, . .	Royal Asiatic Society of Bengal.
SHANGHAI, . .	*China Branch of the Asiatic Society.
TOKIO, JAPAN, .	*Imperial University of Japan.

AUSTRALASIA.

ADELAIDE, . .	*Royal Society of South Australia.
MELBOURNE, . .	*Royal Society of Victoria.
SYDNEY,. . .	*Royal Society of New South Wales.
Do. . . .	*The Australian Museum.
Do. . . .	*Linnean Society of New South Wales.
WELLINGTON, .	*New Zealand Institute.

LIST OF FELLOWS,

As at 30th June 1894.

*Those marked * are Life Members.*

Date of Election.

1893. Adamson, James, M.A., B.Sc., 2 Viewforth Terrace.
1893. Alexander, John, M.D., L.R.C.P., L.R.C.S., D.P.H., Wick.
1856. *Anderson, J., M.D., LL.D., F.R.SS. L. & E., F.L.S., F.Z.S., F.A.S., 71 Harrington Gardens, London, S.W.
1872. Anderson, James, 135 Mayfield Road.
1888. Ap Iwan, Mihangel, M.B., C.M., Independent College, Bala, N. Wales.
1884. Armitage, J. A., B.A., 28 Waterloo Road South, Wolverhampton.
1893. Bailey, Lieut.-Colonel Fred., (*late*) R.E., F.R.G.S., F.R.S.E., 7 Drummond Place.
1884. Baily, Edwin, M.B., C.M., Victoria Crescent, Oban.
1890. Bainbridge, A. F., 18 Clyde Street.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 14 Charlotte Square.
1885. Barrett, W. H., M.B., C.M., 21 Learmonth Terrace.
1884. Beaumont, Alfred, The Red Cottage, Blackheath Park, London.
1880. *Beddard, Frank E., M.A., F.R.S., Zoological Gardens, London.
1875. Bennie, James, Geological Survey, George IV. Bridge.
1881. *Berry, W., of Tayfield, Newport, Fife.
1880. Bird, George, 24 Queen Street.
1891. Bosse, Fr., Edinburgh Geographical Institute, Park Road.
1892. Bowhill, Thomas, F.R.C.V.S., 921 Sutter Street, San Francisco, U.S.A.
1883. Bowie, A. F., 16 Duncan Street, Newington.
1893. Bradley, O. C., M.R.C.V.S., 41 Elm Row.
1876. Brown, J. A. Harvie, F.Z.S., F.R.S.E., Dunipace House, Larbert.
1885. Brown, J. Macdonald, M.B., F.R.C.S., Apsley Lodge, Grange.
1860. *Brown, R., M.A., Ph.D., F.L.S., F.R.G.S., Ferslev, Rydal Road, Streatham, London, S.W.
1891. Brown, Richard, C.A., 23 St Andrew Square.
1876. *Bruce, W. P., Kinleith Mill, Currie.
1894. Bruce, W. S., Mabie, Dumfries.
1882. Bryson, Wm. A., Consulting Electrical Engineer, 28 Gray Street, Kelvingrove, Glasgow.
1885. Buckley, T. E., B.A., F.Z.S., Rossal, Inverness
1894. Burrage, J. H., B.A. (Oxon.), Royal Botanic Garden.
1885. Burt, Robert F., M.B., 124 Stroud Green Road, Finsbury Park, London, N.
1887. Calderwood, W. L., F.R.S.E., 7 Napier Road.

Date of Election.
1886. Campbell, Andrew, Burmah Oil Company, Rangoon.
1893. Campbell, Kenneth Findlater, C.E., Hon.M.Inst.C.E., M.S.I., Town Hall, Stockton-on-Tees.
1892. Carlier, Edmond W., B.Sc., M.D., Physiological Laboratory, The University.
1876. *Carmichael, Sir T. D. Gibson, Bart., Castlecraig, Dolphinton.
1858. Carruthers, W., F.R.S., British Museum, London.
1887. Clarke, E. Wearne, M.D., B.Sc.(Edin.), Kilblean House, Chesterfield.
1888. Clarke, W. Eagle, F.L.S., Museum of Science and Art.
1893. Clemons, G. Ernest, M.B., C.M., Hospital, Launceston, Tasmania.
1893. Coates, H., F.R.S.E., Pitcullen House, Perth.
1881. Cook, C., W.S., 11 Great King Street.
1887. *Corke, H. C., F.R.S., 178 High Street, Southampton.
1892. Corstorphine, George S., B.Sc., 10 St Ronan's Terrace.
1874. Crawford, W. C., M.A., Lockharton Gardens, Slateford.
1892. Dakyns, John Roche, M.A., Geological Survey, George IV. Bridge.
1877. *Dalgleish, J. J., Brankston Grange, Bogside Station, Stirling.
1894. Day, T. Cuthbert, F.C.S., 36 Hillside Crescent.
1885. Dendy, Arthur, B.Sc., c/o Dulau & Co., 37 Soho Square, London, W.
1883. Dickson, G. W., M.A., M.B., C.M., Bridge House, Reevsby, Boston, Lincolnshire.
1894. Dobbie, James Bell, 3A Pitt Street.
1893. Donald, Charles W., M.B., C.M., Kousgarth, Braid Road.
1889. Drieberg, Principal C., Agricultural College, Colombo, Ceylon.
1880. Drummond, W., S.S C., 4 Learmonth Terrace.
1886. Duncan, James, Estate Office, Abercairny, Crieff.
1885. Duncan, J. Barker, W.S., 6 Hill Street.
1883. Dunn, Malcolm, Palace Gardens, Dalkeith.
1864. *Duns, Professor, D.D., F.R.S.E., 14 Greenhill Place.
1888. Edington, Alexander, M.B., C.M., Bacteriological Laboratory, Cape Town, South Africa.
1863. *Edmonston, A., Delta Cottage, Pitlochry.
1889. Elsworth, R. C., M.B., C.M., St Helen's Road, Swansea.
1880. Erskine, W., Oaklands, Trinity Road.
1880. Evans, Wm., F.F.A., F.R.S.E., 18A Morningside Park.
1883. Ewart, Professor Cossar, M.D., F.R.S., The University.
1890. Felkin, Robert W., M.D., F.R.S.E., 8 Alva Street.
1884. Fenton, Gerald A., Bellary, Madras, India.
1882. Ferguson, J., 18 Clyde Street.
1884. Ferguson, James A. E., M.B., Public Lunatic Asylum, Berbice, British Guiana.
1885. Ferguson, James Haig, M.D., F.R.C.P.E., 25 Rutland Street.
1889. Fox, Fortescue, M.D., 7 Albert Mansions, Northumberland Street, London, W.
1887. Fulton, T. Wemyss, M.B., C.M., 23 Royal Crescent.
1884. Geikie, Professor James, D.C.L., F.R.S., The University.
1883. Gibson, E., 1 Eglinton Crescent.
1881. Gibson, J., Ph.D., F.R.S.E., 20 George Square.

Date of Election.

1892. Gilchrist, John D. F., M.A., B.Sc., Ph.D., Carvenom, Anstruther.
1880. Glover, J., S.S.C., 1 Hill Street.
1889. Goodchild, J. G., F.Z.S., F.G.S., Museum of Science and Art.
1894. Greenly, Edward, F.G.S., Geological Survey, George IV. Bridge.
1877. Grieve, S., 21 Queen's Crescent.
1886. Grieve, Symington, 11 Lauder Road.
1893. Grimshaw, Percy H., Museum of Science and Art.
1887. Gunn, John, F.R.S.G.S., 4 Parkside Terrace, *Secretary*.
1893. Guppy, H. B., M.B., C.M., F.R.S.E., 6 Fairfield West, Kingston-on-Thames.
1887. Hailes, Clements, D.G., M.B., C.M., M.D., 11 King's Parade, White Ladies' Road, Clifton, Bristol.
1883. Hallen, J. H. B., Pebworth Fields, Broad Marston, Stratford-on-Avon.
1881. Hamilton, R., Trinity Lodge, Trinity.
1883. Henderson, Professor, M.B., F.L.S., Christian College, Madras.
1883. Hepburn, David, M.D., The University.
1879. Herdman, Professor, D.Sc., F.R.S.E., University College, Liverpool.
1884. Hinxman, Lionel, B.A., Geological Survey, George IV. Bridge.
1882. Hogg, A., 94 George Street.
1892. Holt, Henry Mainwaring-, M.R.C.S., L.S.A., Malton, Yorks.
1886. Horn, Wm., Advocate, Woodcote Park, Blackshiels, Midlothian.
1878. Horne, J., F.G.S., Geological Survey, George IV. Bridge.
1884. Howell, Henry H., Geological Survey, George IV. Bridge.
1883. Hoyle, W. E., M.A., F.R.S.E., Owens College, Manchester.
1891. Hughes, Alfred W., M.B., F.R.C.S.E., Woodside, Musselburgh.
1892. Hughes, Hugh Lewis, Surgeon, Dowlais, South Wales.
1891. Hunter, David, S.S.C., 29 Dundas Street.
1880. Hunter, James, F.R.C.S.E., F.R.A.S., Rosetta, Liberton.
1874. Hunter, John, F.C.S., Minto House, Chambers Street.
1878. *Hunter, J. R. S., LL.D., Daleville, Braidwood, Lanarkshire.
1888. Hutchinson, Alfred, B.Sc., The Leys, Cambridge.
1877. Joass, Edward C., F.F.A., Standard Life Insurance Co., 3 George Street.
1880. Johnston, J. A., 7 Annandale Street.
1893. Jong, E. F. de, M.R.C.V.S., 42 Elm Row.
1886. Kelso, J. E. H., M.B., C.M., Downlee, St Andrews Road, Elmgrove, Southsea, Hants.
1881. Kemp, D. W., Ivy Lodge, Trinity.
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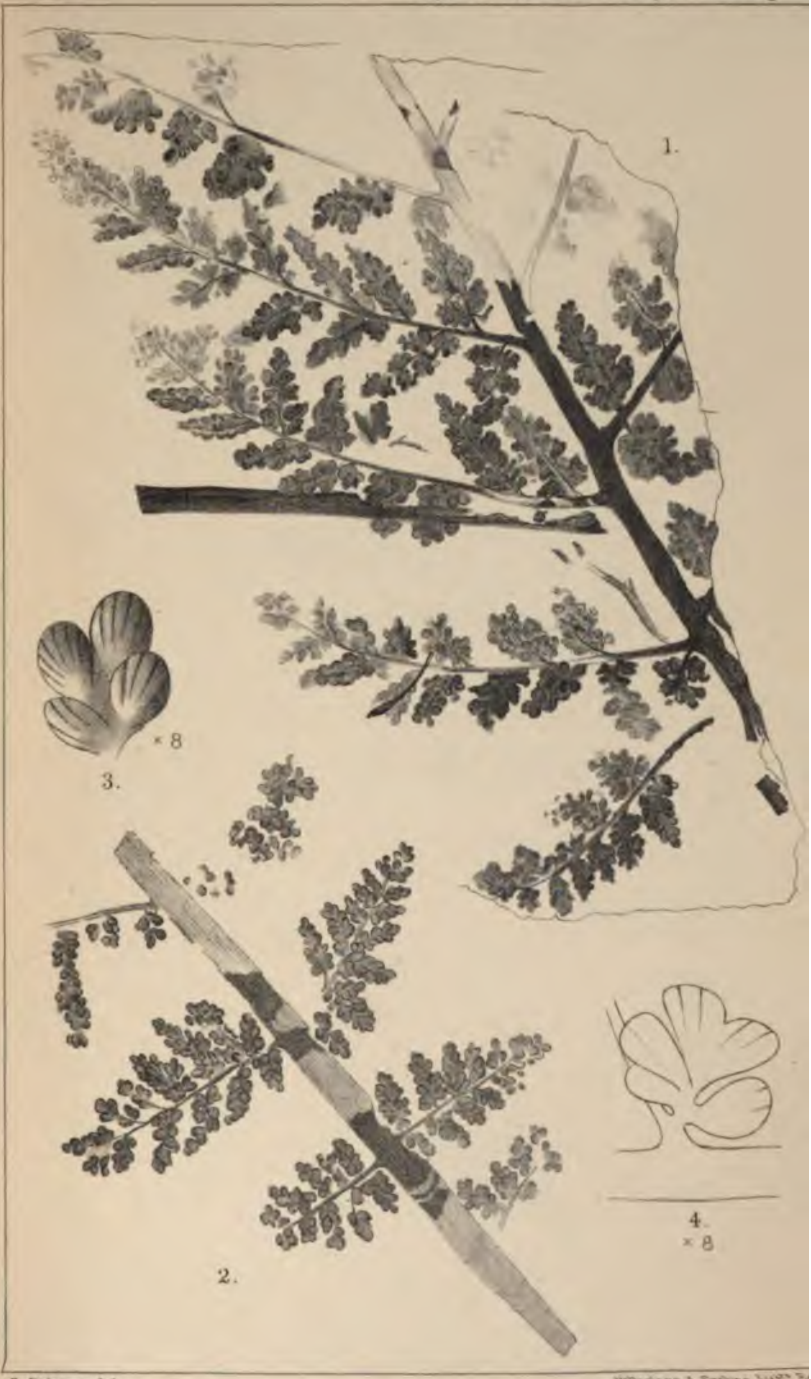

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SPHENOPTERIS DUNSII, Kidston, n. sp.

PLATE V

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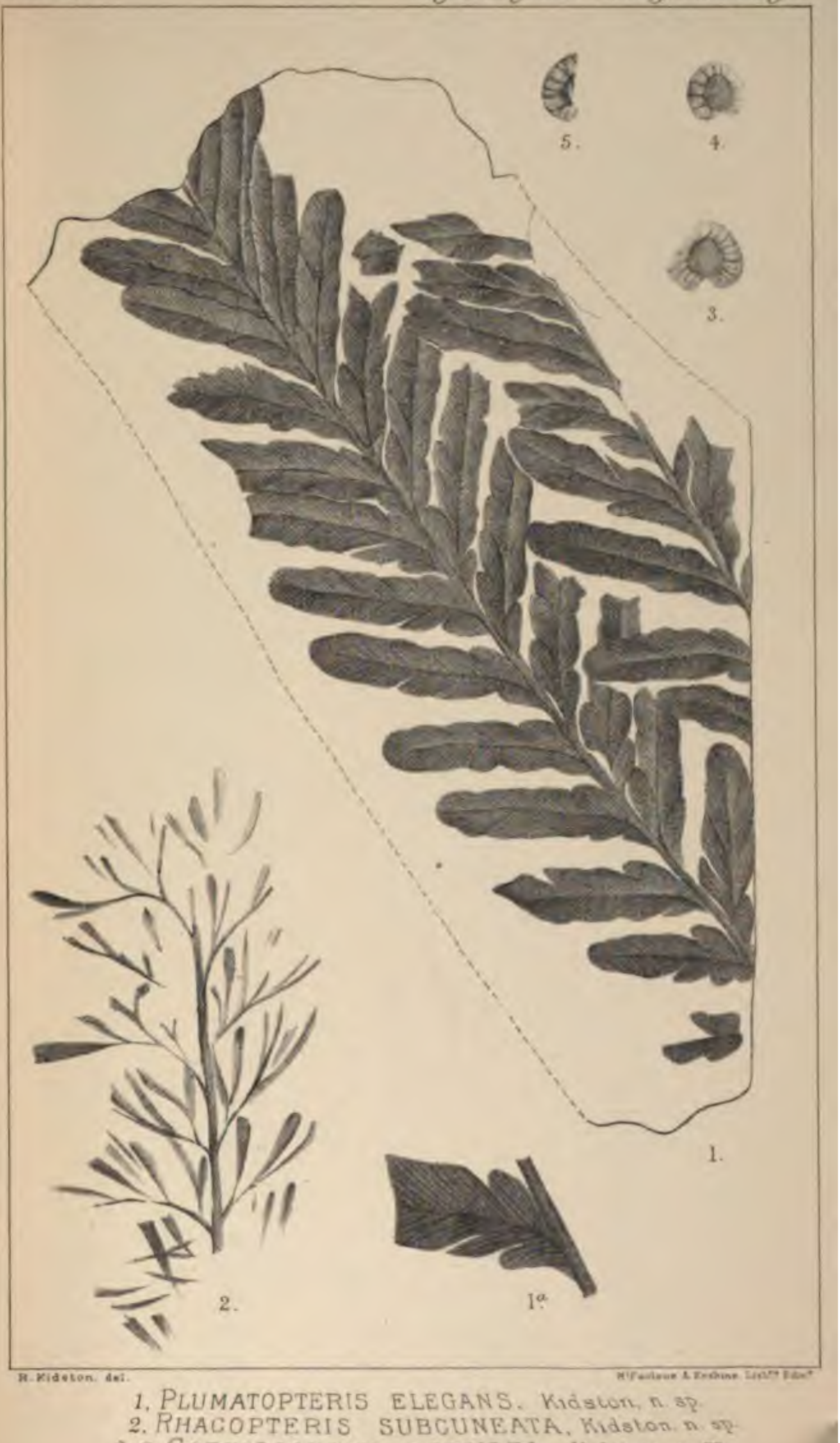

R. Kidston, del. M'Farlane & Erskine, Lithrs Edinr

1. PLUMATOPTERIS ELEGANS. Kidston, n. sp.
2. RHACOPTERIS SUBCUNEATA, Kidston, n. sp.
3-5. CARDIOCARPUS NERVOSA, Kidston, n. sp.

PLATE VI

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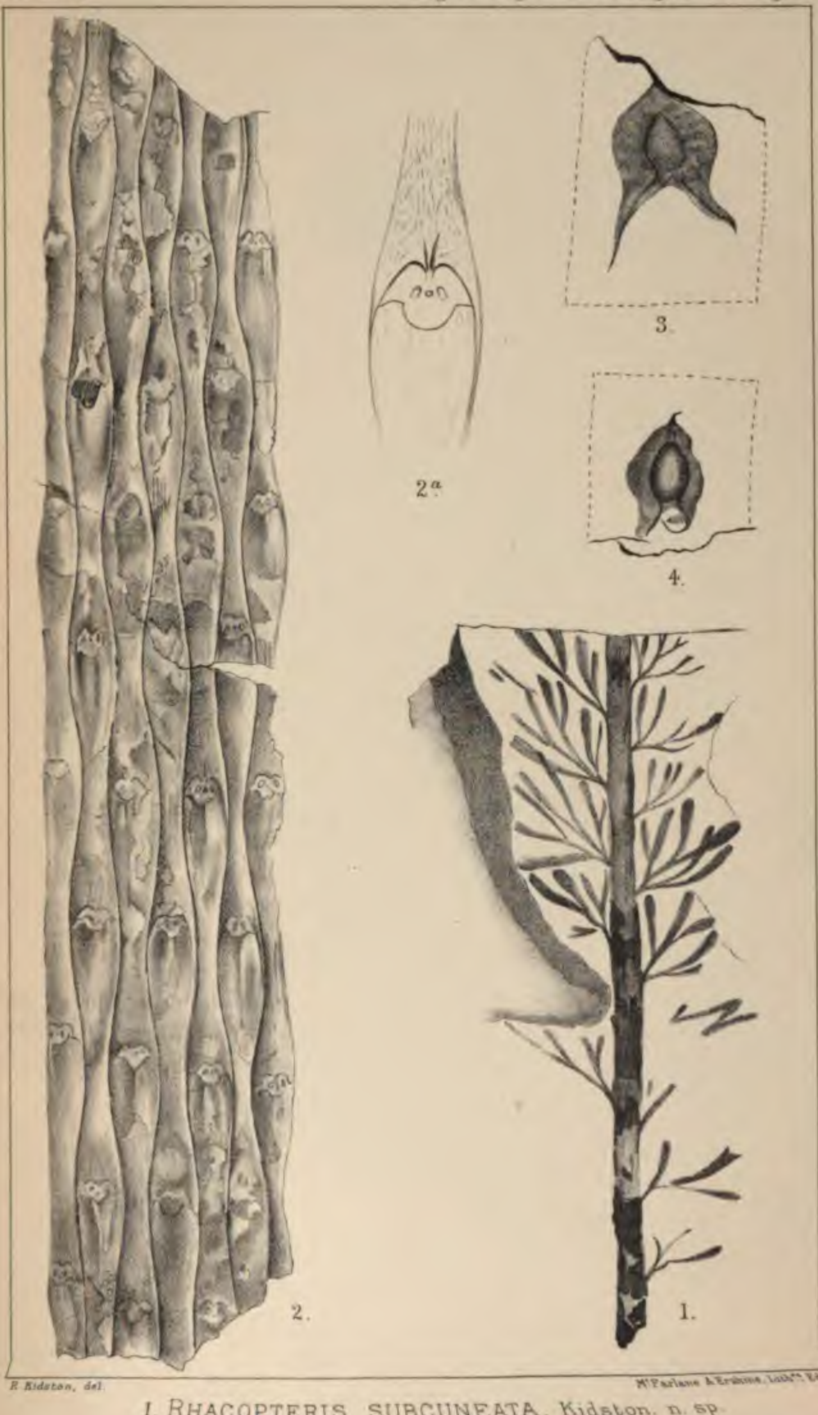

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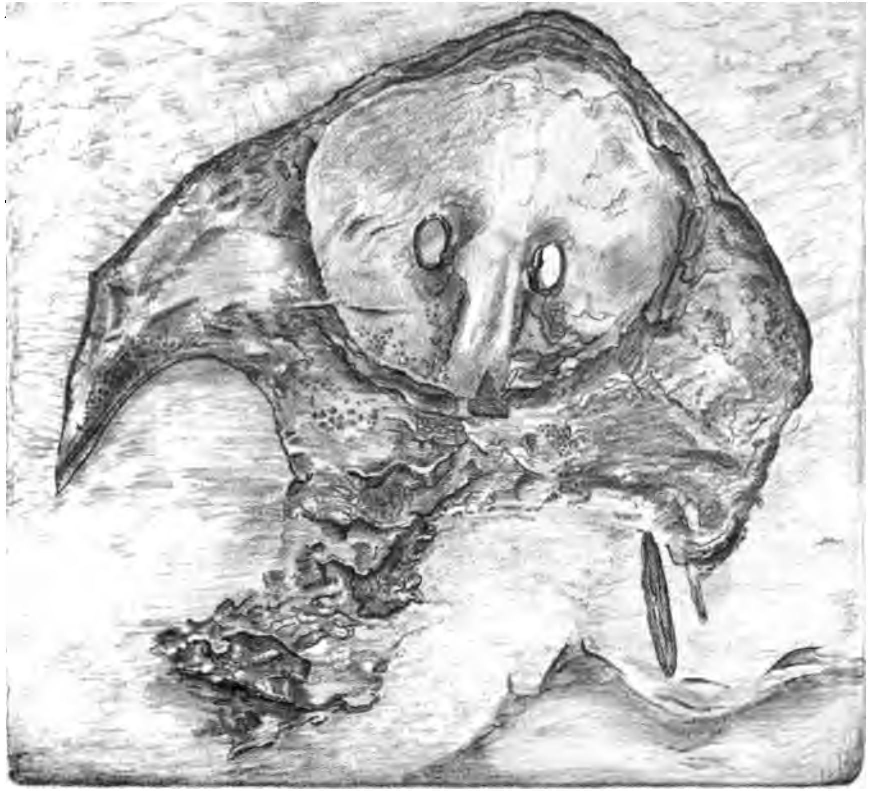
1. RHACOPTERIS SUBCUNEATA, Kidston, n. sp.
2. SIGILLARIA YOUNGIANA, Kidston, n. sp.
3. CARDIOCARPUS BICAUDATUS, Kidston, n. sp.



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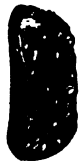

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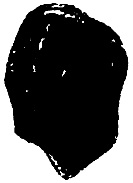

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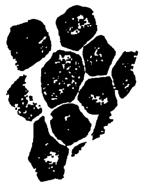

Fig. 4.

R. H. Traquair ad nat. del.

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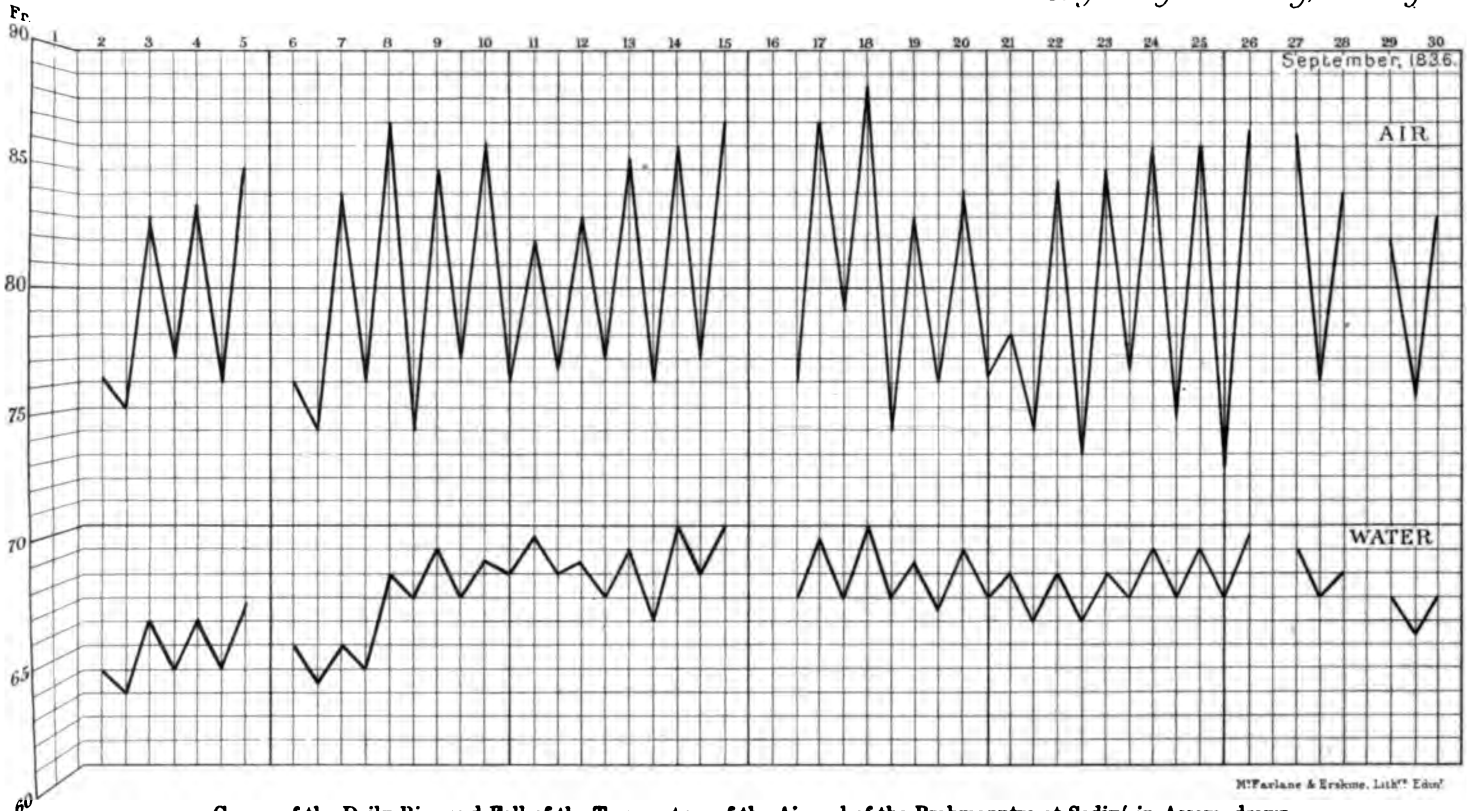
PLATE VIII.



Curves of the Daily Rise and Fall of the Temperature of the Air and of the Brahmaputra at Sadiyá in Assam, drawn

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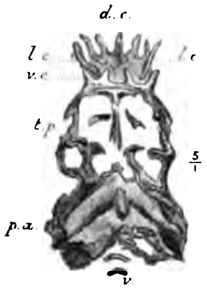

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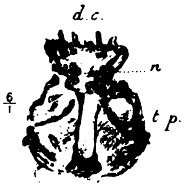

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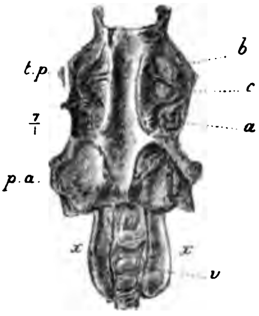

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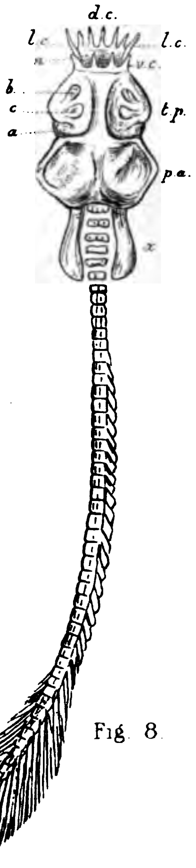

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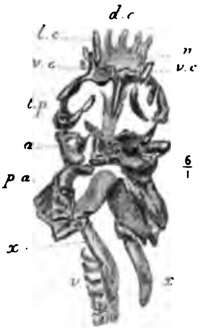

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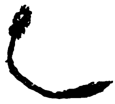

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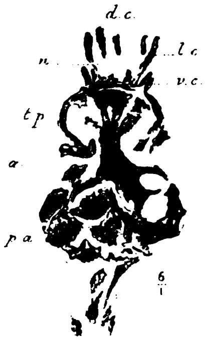

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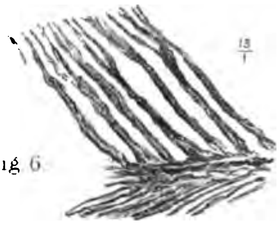

Fig 6.

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PALÆOSPONDYLUS GUNNI. Traquair.

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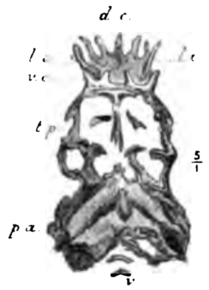

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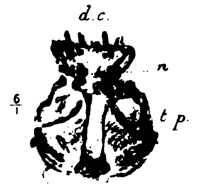

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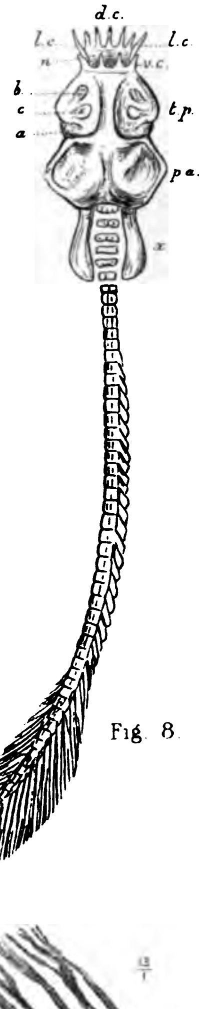

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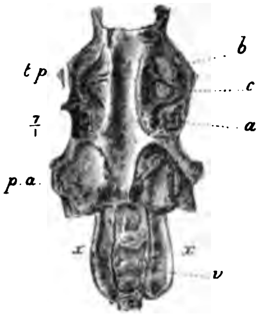

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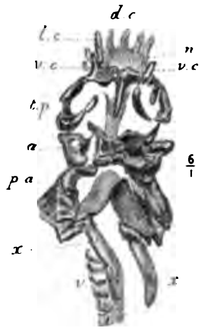

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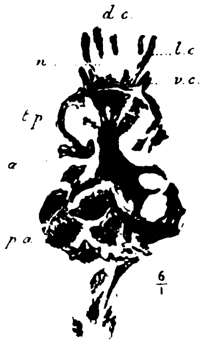

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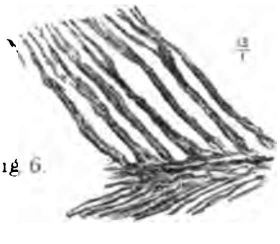

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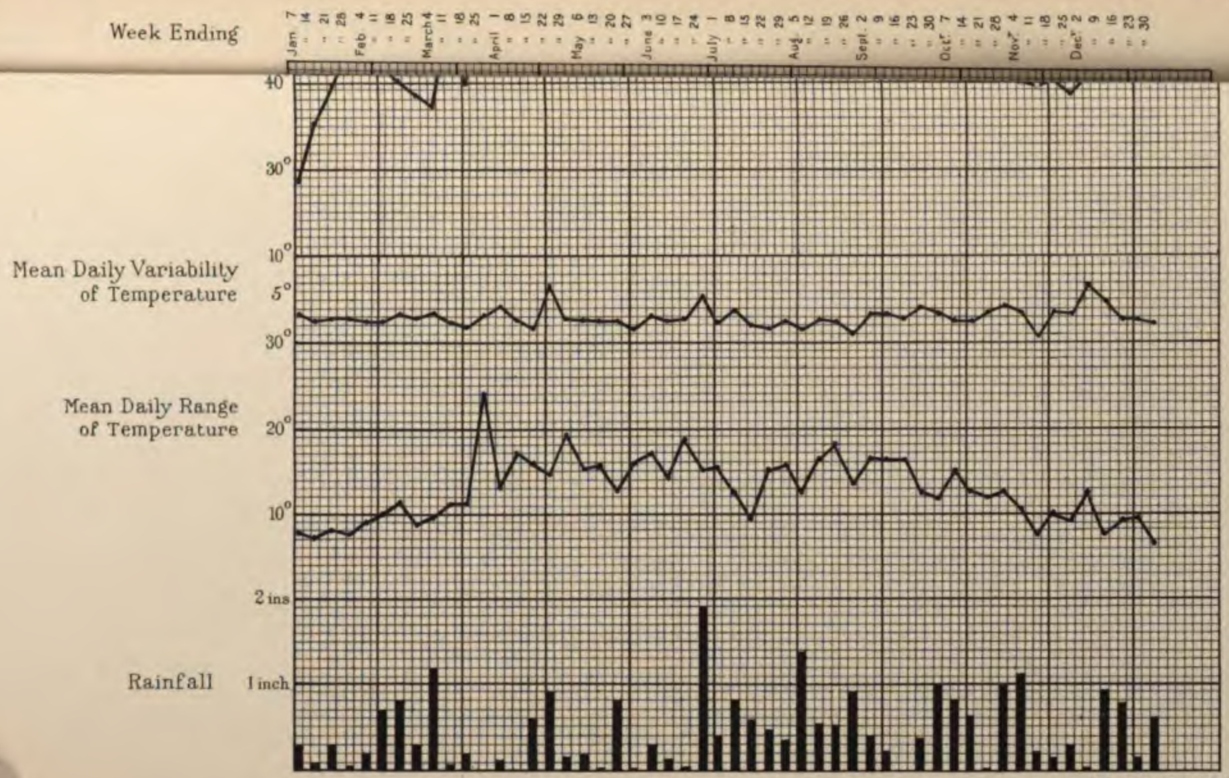

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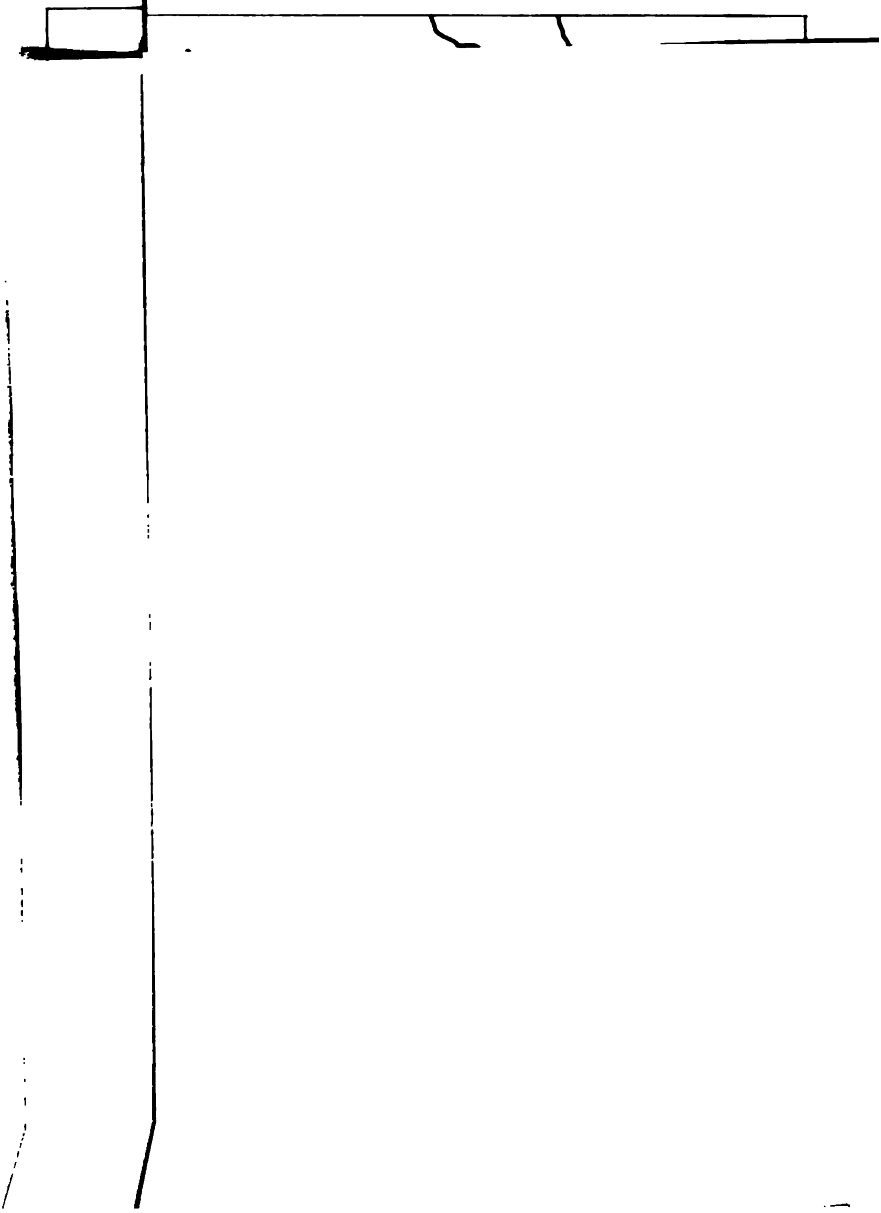

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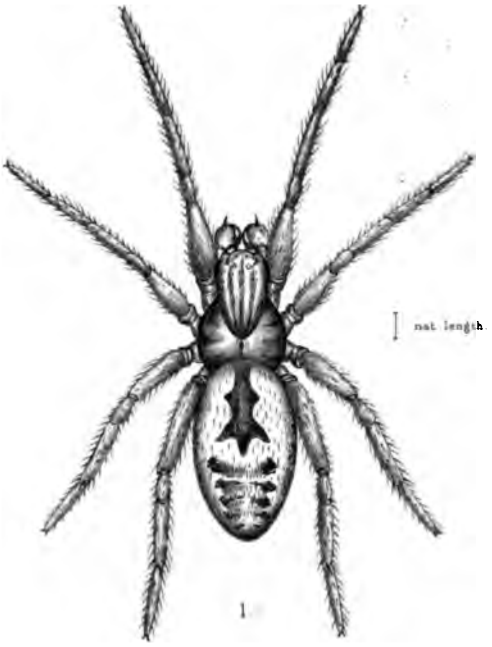

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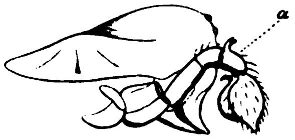

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